FINAL FOCUSED FEASIBILITY STUDY FOR OPERABLE UNIT 3 (OU3) NORTH PENN AREA 7 SUPERFUND SITE NORTH WALES, MONTGOMERY COUNTY, PENNSYLVANIA

Prepared for:

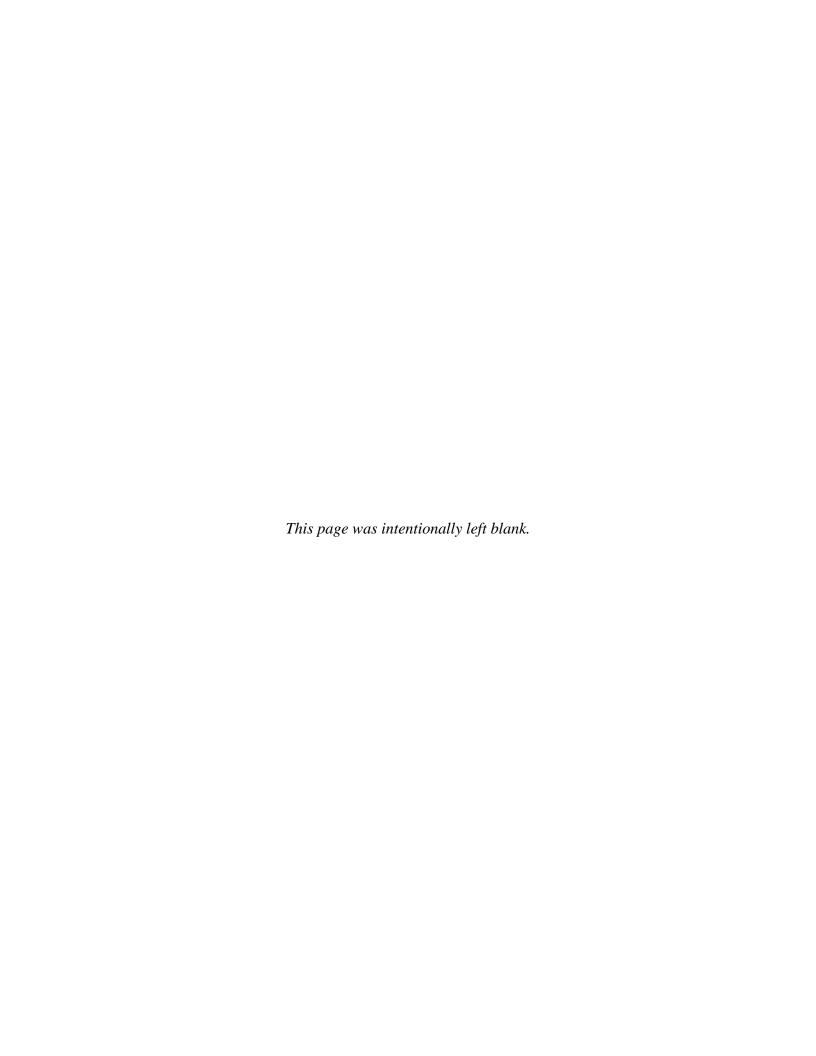


U.S. Environmental Protection Agency Region 3 1650 Arch Street Philadelphia, PA 19103

> EPA Contract EP-S3-07-05 Work Assignment 046RICO03X1

> > December 2019





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Prepared by:

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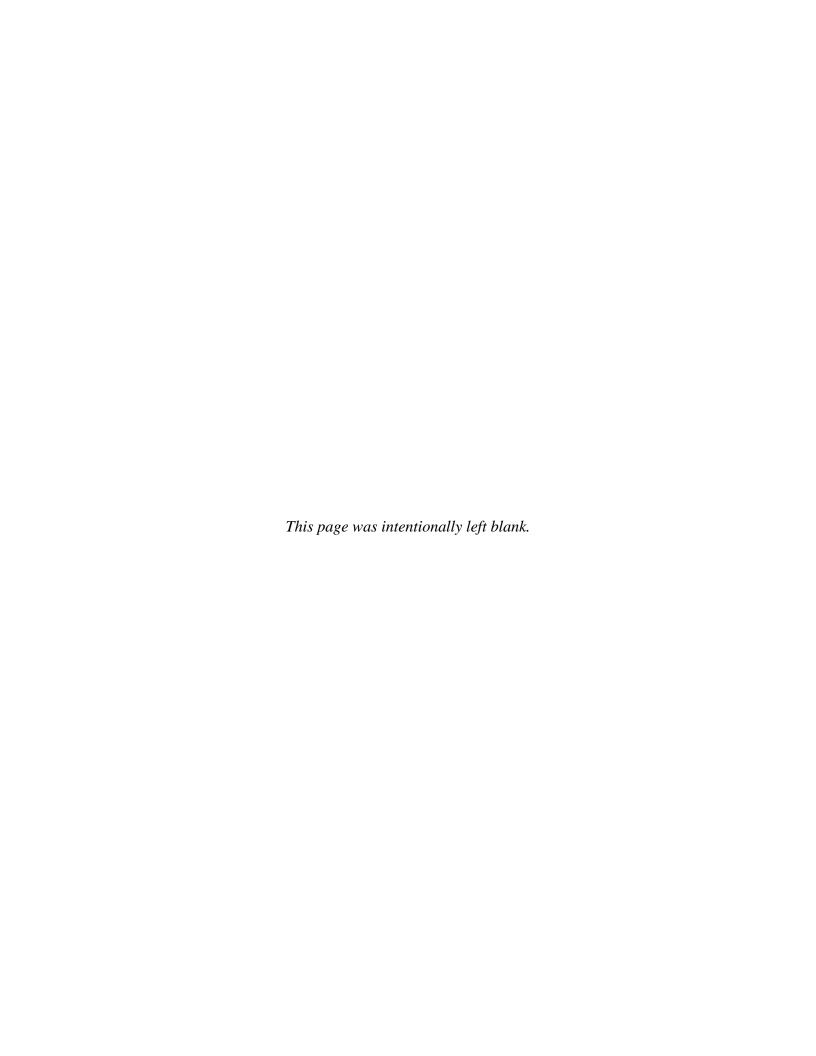


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LIST OF ACRONYMS AND ABBREVIATIONS

μg/L micrograms per liter

1,1,1-TCA 1,1,1-trichloroethane

Air Code Air Pollution Control Code

amsl above mean sea level

ARAR Applicable or Relevant and Appropriate Requirements

bgs below ground surface

CAA Clean Air Act

CERCLA Comprehensive Environmental Response, Compensation, and Liability

Act

CFR Code of Federal Regulations

cis-1,2-DCE cis-1,2-dichloroethane
COC contaminant of concern
CTE central tendency exposure

CWA Clean Water Act

EISB enhanced in situ bioremediation

EOS emulsified oil substrate

EPA (U.S.) Environmental Protection Agency

FERCO Ford Electronics and Refrigeration Corporation

FFS Focused Feasibility Study

FS Feasibility Study

ft foot/feet

ft² square foot/feet FYR Five-Year Review

GETS groundwater extraction and treatment system

GRA general response action

HGL HydroGeoLogic, Inc.

HI Hazard Index

IC institutional control
ISCO in situ chemical oxidation
ISTD in situ thermal desorption

Leeds and Northrup Incorporated

LTM long-term monitoring

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

MCL maximum contaminant level MNA monitored natural attenuation

NCP National Oil and Hazardous Substances Pollution Contingency Plan

NPL National Priorities List NPWA North Penn Water Authority

O&M operation and maintenance

OSWER Office of Solid Waste and Emergency Response

OU Operable Unit

PADEP Pennsylvania Department of Environmental Protection

PCB polychlorinated biphenyl

PCE tetrachloroethene

PHWMR Pennsylvania Hazardous Waste Management Regulations

PLFA phospholipid fatty acid

PPE personal protective equipment

PPRTV Provisional Peer Reviewed Toxicity Values

PRB permeable reactive barrier
PRG preliminary remedial goal
PRP potentially responsible party
psi pounds per square inch

RA remedial action

RAC Remedial Action Contract RAO remedial action objective

RCRA Resource Conservation and Recovery Act

RD Remedial Design
RI Remedial Investigation

RME reasonable maximum exposure

ROD Record of Decision ROI radius of influence

RSL Regional Screening Level

SARA Superfund Amendments and Reauthorization Act of 1986

Site North Penn Area 7 Superfund Site

Spra-Fin Spra-Fin Incorporated SVE Soil vapor extraction

TBC to be considered TCE trichloroethene

Teleflex Teleflex Incorporated TOC total organic carbon

TPO technology process option

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

Underground Injection Control U.S. Geological Survey UIC

USGS

VFA volatile fatty acid vapor intrusion VI

volatile organic compound VOC

Zenith Electronics Corporation Zenith

EXECUTIVE SUMMARY

This Focused Feasibility Study (FFS) has been prepared for Operable Unit 3 (OU3) (groundwater) for the North Penn Area 7 Superfund Site (Site). This FFS has been conducted by HydroGeoLogic, Inc. (HGL) for the U.S. Environmental Protection Agency (EPA), Region 3, under Remedial Action Contract (RAC) EP-S3-07-05. This FFS has been prepared in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA). The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 Code of Federal Regulations [CFR] Part 300) establishes the framework for FSs.

The purpose of this FFS Report is to develop, evaluate, and compare remedial alternatives that could be feasible for addressing potential risks to human health and the environment posed by contaminated groundwater at the Site. The scope of this FFS is based on discussions with EPA and information obtained from historical documents regarding site investigations.

SITE DESCRIPTION

The Site is located in North Wales, Montgomery County, Pennsylvania, and covers approximately 650 acres. The Site consists of five former manufacturing facilities where solvents have been used as listed below:

- The 1.1-acre former Spra-Fin Incorporated (Spra-Fin) metal manufacturing and finishing business located on Wissahickon Avenue;
- The 36-acre former Ford Electronics and Refrigeration Corporation (FERCO) electronics and electrical auto parts manufacturing facility located at 1190 Church Road;
- The 23-acre former Teleflex Incorporated (Teleflex) facility located at 205 Church Road where mechanical, electrical, and pneumatic control devices were manufactured for the aircraft industry;
- The 50-acre former Leeds and Northrup Incorporated (Leeds and Northrup) electronic instruments manufacturing plant located at 351 Sumneytown Pike; and
- The 52.8-acre former Zenith Electronics Corporation (Zenith) television picture tube manufacturing facility located at 1180 Church Road.

For the purposes of remediation, EPA has divided the Site into four OUs, with OU1 and OU2 dealing with Site soil contamination. OU1 is the potentially responsible party (PRP)-led investigation and remedial action (RA) at four of the five former facilities: FERCO, Teleflex, Leeds and Northrup, and Zenith properties. OU2 consists of a Superfund-led investigation and RA at the Spra-Fin property. OU3 consists of Sitewide groundwater contamination, and OU4 addresses vapor intrusion (VI) related to Site contaminants. This FFS addresses OU3.

SITE HISTORY

Contamination was initially found at the North Penn 7 Site in 1979 by the North Penn Water Authority (NPWA) when trichloroethene (TCE) contamination was discovered in well L-22 (part

of a well field with seven production wells). Two other wells in the production well field, L-17 and L-12, were subsequently sampled and also contained TCE. Wells L-17 and L-22 were left in operation to provide hydraulic control of the contaminant plume and help prevent further migration.

In 1986 EPA sent CERCLA 104(e) requests for information to facilities in the area, including Spra-Fin, Teleflex, Leeds and Northrup, and Zenith. Information was provided to EPA from these facilities over the next year. During this time, EPA also sent a CERCLA 104(e) request to FERCO and received their response.

The site discovery phase of the CERCLA process was completed in 1986 by NUS Corporation under an EPA contract. Based on the resulting Hazard Ranking System score, the Site was proposed for listing on the National Priorities List (NPL) in 1987. The Site was added to the NPL in 1989, with the five facilities listed above having been determined to be the primary sources of groundwater contamination. A summary of each source area is provided below.

TELEFLEX

Teleflex developed this 23-acre property and operated a manufacturing facility for electronic, mechanical, and pneumatic control devices in 1956 and 1957. The Teleflex property consists of two buildings (Building 100 and Building 300). Outdoor wastewater treatment facilities were located adjacent to each building.

Throughout its operation, Teleflex used TCE and 1,1,1-trichloroethane (1,1,1-TCA) for cleaning metal parts in Building 100, the main building. Building 300 included a paint booth, although no chlorinated solvents were reported to have been used in the painting process. Based on past investigations, this facility is a potential soil source of TCE, 1,1,1-TCA, tetrachloroethene (PCE), and cis-1,2-dichloroethene (cis-1,2-DCE). Groundwater samples collected from overburden and shallow and intermediate bedrock wells for several years indicate that the highest concentrations of TCE were found within the vicinity of the Former Drum Storage Area, specifically from well T-7 (6,000 micrograms per liter $[\mu g/L]$).

ZENITH

The former Zenith property encompasses 52.8 acres and consisted of a 400,000-square-foot [ft²]) manufacturing building and a smaller building with office and commercial space (see maps in Appendix A). An asphalt and concrete parking lot is located between the two buildings. Philco Corporation purchased the property in 1961 and in 1966 constructed the first building as a television picture tube manufacturing facility. Zenith purchased the property in 1973 and continued picture tube manufacturing activities for about 18 months, until December 1974 when the plant was closed. From 1966 through 1974, the former Zenith facility was reported to have used several thousand gallons of TCE each year. The TCE was delivered in drums, and waste TCE was reported to have been stored temporarily before being disposed of off site. Based on past investigations, this facility is a potential soil source of TCE, vinyl chloride, 1,2-dichloroethane, and cis-1,2-DCE. Groundwater samples contained up to 1.6 μ g/L of TCE and 0.9 μ g/L of 1,1,1-TCA.

FERCO

The property consists of about 36 acres located at the intersection of Church Road and Wissahickon Avenue. Most of the land was at one time covered by buildings, asphalt, or concrete pavement. In 1993, all structures were demolished except Building 40-X, and some small ancillary structures. Beginning in 1947, the property was used for several manufacturing processes, and from 1994 to 1997 Building 40-X was the site of an electronics degreasing facility. The six degreasers housed in this building used TCE for cleaning electronic parts. Based on past investigations, this facility is a potential soil source of metals, volatile organic compounds (VOCs) (primarily TCE), and polychlorinated biphenyls (PCBs). Groundwater samples collected from one of the 500-foot deep bedrock production wells consistently contained TCE at levels between 250 μ g/L and 500 μ g/L, with a maximum detected concentration of 1,000 μ g/L; 1,1,1-TCA had been detected in this well at 50 μ g/L. All production wells were abandoned by 2005.

LEEDS AND NORTHRUP

This property encompasses approximately 50 acres and included a 643,000-ft² manufacturing building and a 120,000-ft² Technical Center (both are now demolished). Additional support buildings included a boiler house, an electrical substation, a metal salvage building, a hazardous waste storage building, and a flammable liquid storage building. In 1953, Leeds and Northrup developed the land for the manufacture of process control instruments. The Technical Center was built in 1950. Chlorinated solvents (mainly TCE and 1,1,1-TCA) were used in the manufacturing building as degreasing agents. Waste manifests indicate that, between 1981 and 1985, an average of 1,753 gallons of waste TCE was removed from the Site annually. Other documented solvent removals included: methylene chloride (55 gallons between 1985 and 1986), Freon (165 gallons between 1981 and 1985), and "unspecified solvent" (1,463 gallons between 1979 and 1980). Past investigations indicate this property is a potential soil source TCE, cis-1,2-DCE, 1,1-DCA, 1,1,1-TCA, and PCE. Groundwater samples collected from uncased borings contained up to 941 μ g/L of TCE, up to 323 μ g/L PCE, and up to 593 μ g/L 1,1,1-TCA.

SPRA-FIN

Spra-Fin began operations in 1963, using several production lines to paint metals and plastic parts for other manufacturers. The facility used a 100-gallon vapor degreasing unit with TCE as the primary degreasing solvent. In their CERCLA 104(e) response, Spra-Fin reported the purchase of 1,350 gallons of TCE in 1978 and 1,560 gallons in 1985. Other records indicate that Spra-Fin used 82 gallons of TCE per month (CDM, 1987). Other products purchased in 1986 included toluene (5 gallons) and xylene (1,000 gallons), 15 gallons of black lacquer and 495 gallons of paint (CDM, 2011). Based on past investigations this site is a potential soil source of VOCs, primarily TCE. Groundwater samples collected from the borings near the old storage tank location had TCE concentrations of 262,150 μ g/L and 199,000 μ g/L. PCE and 1,1,1-TCA concentrations of 2,920 μ g/L and 3,670 μ g/L, respectively, were also reported for these locations. Four former production wells installed in bedrock are located on the Spra-Fin property. Samples from these wells have typically contained TCE at concentrations greater than 500 μ g/L. During a 1981 pumping test, the TCE concentration detected in samples from Spra-Fin Well No. 2 was 36,605 μ g/L. In March 1984, vinyl chloride was detected in one production well at 947 μ g/L (CH2M Hill, 1992).

SITE CONDITIONS SUMMARY

Site topography consists of gently to moderately undulating hills, with the tops of ridges being moderately broad and with gentle slopes. Slopes may steepen in valley bottoms where surface water flows through streams. The elevation of the Site varies between approximately 430 feet (ft) above mean sea level (amsl) to approximately 280 ft amsl. The higher areas of the Site occur to the eastern boundary of the Site, and the lowest area occurs near the northwestern boundary, at the Towamencin Creek.

Site soils are varied due to the size of the Site and the extensive development of the area. Generally, the Site is underlain by Chalfont silt loam, a subcategory to the Chalfont Series. This soil is characterized as very silty and with a slowly permeating subsurface layer which can restrict downward flow of water. The surface layer is a silt loam of up to 18 inches thick, and a reddish-brown shaley soil underlies the surface layer. Due to the lower permeability of the substratum, perching of water may occur during the wetter season of late fall to early spring.

The Site is located in the Triassic Lowlands of the Piedmont Physiographic Province. The Piedmont province is made up of three sections in this region: the Piedmont Upland, the Piedmont Lowland, and the Gettysburg-Newark Lowland.

Newark group units comprise the bedrock directly underlying the North Penn 7 site. The Newark group is made of Triassic aged mudstone, shale, and sandstone. The section often has a characteristic reddish brown color. The major formations in this section, from oldest to youngest, are the Stockton, Lockatong, and Brunswick formations. Together these formations represent the Newark group, and were deposited as lacustrine, fluvial, and alluvial sediments in the Newark rift basin.

Generally, the structure of the bedding planes in this group is characterized by a northeast/southwest strike, and between 5 to 20 degrees of dip toward the northwest. The Newark group in this area is an interfingered zone of contact between the Lockatong and Brunswick formations. This causes the bedrock at the surface to alternate, with three sections of Lockatong Formation separated by two sections of Brunswick Formation. The Lockatong Formation is a gray, argillaceous shale interbedded with thin beds of gray to black shale and siltstone. The Brunswick Formation is made of soft red shale, siltstone, and sandstone.

Fractures and jointing occur here and enhance overall porosity of the formations. Within these joints and fractures, quartz and calcite commonly occur. There are three joint sets that have been reported in the vicinity of the Site. The most developed set strikes at approximately 30 degrees east (N30E). The other two sets strike at approximately N45W, and N75E. All three joint sets are reported to be nearly vertical, and are narrower and more widely spaced in the Lockatong Formation than in the Brunswick Formation. A dominant fracture pattern was documented during a fracture trace analysis performed for the Spra-Fin facility, showing fractures trending approximately north-northeast.

The Lockatong and Brunswick formations have little primary permeability, and as such almost all groundwater movement occurs through intersecting fracture sets. The well-developed, nearly vertical jointing occurring in the formations also are primary pathways for groundwater movement.

The Brunswick Formation has been extensively developed for groundwater supply through the Brunswick aquifer. This aquifer is strongly anisotropic, and hydraulic conductivity is greatest parallel to bedding strike. Supply wells capable of yielding tens to hundreds of gallons a minute have been completed throughout the formation, generally at depths of 200 to 500 ft. Groundwater in the Lockatong Formation yields an average of approximately 7 gallons per minute.

For OU3, groundwater monitoring wells are classified as upper, middle, lower, and lowest, based on their screened interval depths within the fractured bedrock. Upper bedrock wells are generally completed to depths above 270 ft amsl, middle bedrock wells are completed to depths between 200 ft amsl, lower bedrock wells are completed to depths between 100 and 200 ft amsl, and lowest bedrock wells are screened below 100 ft amsl. The most recent groundwater elevation readings were collected in July 2016 and reported that depth to groundwater ranges from 6 ft below ground surface (bgs) to 91 ft bgs.

REMEDIAL ACTION OBJECTIVES AND ARARS

CERCLA requires that selected remedies attain a degree of cleanup that ensures protection of human health and the environment. Selected remedies also must comply with the substantive requirements of all Applicable or Relevant and Appropriate Requirements (ARARs). The remedial action objectives (RAOs) for the groundwater at the Site are generic goals that have been developed to achieve protection of human health and the environment.

The only ecological exposure route identified at the Site was the groundwater discharge to surface water and wetlands in the form of potential seeps that were observed in the wetland adjacent to Towamencin Creek. This exposure route was evaluated in the OU1 Baseline Ecological Risk Assessment of Aquatic Habitats and determined that the wetland sediment poses a potential risk to terrestrial invertebrate/plant communities (CDM, 2012a). The chemicals determined to be potential ecological risks are not attributable to the groundwater contaminants and therefore will be addressed under OU1.

Any potential VI risk associated with groundwater will be addressed under OU4.

Based on the risk assessment completed for the Remedial Investigation (RI), some Site contaminants occur at levels that pose possible risks to human health from potential exposure to groundwater. Therefore, the following RAOs related to restoration of Site groundwater and protection of human health were developed.

- Prevent exposure to Site-related groundwater contamination that would result in a target organ hazard index (HI) greater than 1 for non-carcinogens in the groundwater via the potential exposure routes of inhalation, ingestion and dermal absorption.
- Prevent exposure to Site-related carcinogens in groundwater at concentrations that would result in a cumulative cancer risk in excess of 1x10⁻⁴ (1E-04) via the potential exposure routes of inhalation, ingestion, and dermal contact.
- Meet the ARARs for the Site.
- Restore the contaminated groundwater to its beneficial use as a potable water supply.

To ensure that the selected remedy would also meet the requirements of federal and state regulations and guidance, a comprehensive review of these documents was performed to identify ARARs for the Site. These ARARs were used in development of the preliminary remedial goals (PRGs) and in development and screening of potential remedial alternatives for the Site.

PRELIMINARY REMEDIATION GOALS

As indicated by the RAOs, the only medium requiring remediation is groundwater.

The PRGs were obtained from several sources in the following hierarchy:

- For those chemicals that have an EPA Maximum Contaminant level (MCL) and were identified as a contaminant of concern (COC), the MCL was selected as the cleanup goal; and
- For those chemicals that do not have an MCL and were identified as a COC, the cleanup goal was based on the tap water Regional Screening Level (RSL) (cancer risk = 1E-06, non-cancer hazard quotient = 1).

VOLUME CALCULATION

To calculate the volume of contaminated groundwater that exceeds PRGs, data from the 2016 sampling event was used where available. However, because of access issues, certain wells could not be sampled in 2016. To address this, data from the 2006 sampling event were used to fill in the data gaps. Based on the combined data, the contamination was split into two plumes, northern and southern. The northern plume extends from the former Ford facility to the southwest past the former Teleflex facility. The southern plume extends from the northeast of the former Spra-Fin facility to the west/southwest by the former Leeds facility and former Northrup facility. The northern plume covers an area of approximately 2,750,000 square feet (ft²) and a thickness of approximately 250 ft. Assuming an average porosity of 10 percent, the minimum volume of contaminated groundwater that is present would be approximately 514,000,000 gallons. The southern plume covers an area of approximately 3,700,000 ft² with a thickness of approximately 250 ft. Assuming an average porosity of 10 percent, the minimum volume of contaminated groundwater that is present would be approximately 692,000,000 gallons. Therefore, the total minimum volume of contaminated groundwater present at the Site would be approximately 1,206,000,000 gallons.

TECHNOLOGY PROCESS SCREENING AND DEVELOPMENT OF ALTERNATIVES

Technology Process Options (TPOs) representing a range of technology types with the potential to address at least some portion of OU3 contamination were identified. These TPOs were then screened based on their ability to treat OU3 contamination, feasibility for implementation, and relative costs of implementation.

Those TPOs that were retained were assembled into five remedial alternatives that could potentially meet the RAOs for the Site:

• Alternative 1: No Additional Action (required)

- Alternative 2: Monitored Natural Attenuation (MNA) and Institutional Controls (ICs)
- Alternative 3: Groundwater Extraction Treatment (GET) with MNA and ICs
- Alternative 4: In Situ Chemical Oxidation (ISCO) with MNA and ICs
- Alternative 5: Enhanced In Situ Bioremediation with MNA and ICs

EVALUATION OF ALTERNATIVES

The assembled alternatives were then screened qualitatively based on their effectiveness, implementability, and cost. Based on the results of the initial screening, Alternatives 1, 3, 4, and 5 were carried forward for detailed evaluation and comparison based on the following seven criteria specified in the RI/FS Guidance and consistent with the NCP:

- 1) Overall protection of human health and the environment
- 2) Compliance with ARARs
- 3) Long-term effectiveness and permanence
- 4) Reduction of toxicity, mobility or volume
- 5) Short-term effectiveness
- 6) Implementability
- 7) Cost

The major findings of the detailed evaluation of the three alternatives based on the seven evaluation criteria are summarized in the following sections.

OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

The appropriate implementation of ICs under Alternatives 3, 4, and 5 would cut off exposure pathways and thereby eliminate potential risks to human health. Alternatives 3, 4, and 5 would all reduce human health risks from groundwater in the source areas to the levels below the PRGs by either extracting and treating contaminated groundwater or injecting specific amendments. ICs, implemented as part of all three alternatives, would ensure protection of human health until PRGs are achieved. Following containment or treatment of the source area contamination, MNA would be effective in reducing human health risks in the distal plume areas.

COMPLIANCE WITH ARARS

Assuming that Alternatives 3, 4, and 5 are implemented properly, each should achieve compliance with all identified ARARs in a reasonable timeframe. It is likely that Alternative 3 would take longer to achieve compliance with ARARs than either of the two in situ treatment alternatives. The provisions of the Clean Water Act and the regulations of the National Emissions Standards for Hazardous Air Pollutants are the most significant for Alternative 3. For all three alternatives, the Resource Conservation and Recovery Act (RCRA) and Pennsylvania Hazardous Waste Management Regulations sections are applicable for categorization, handling and disposal of any solid or liquid waste. Alternatives 4 and 5 must also comply with the provisions of the Underground Injection Control (UIC) Regulations.

LONG-TERM EFFECTIVENESS AND PERMANENCE

Alternatives 3, 4, and 5 have the potential to be equally effective over the long term because the most contaminated areas would be remediated with groundwater extraction or amendment injections. The treatment of the contaminated groundwater through the two GET Systems in Alternative 3 would require the longest time to achieve cleanup goals. Multiple rounds of oxidant or emulsified oil substrate injections would be required to achieve the PRGs in Alternatives 4 and 5 but in a considerable shorter timeframe than Alternative 3.

The least amount of uncertainty with respect to treatment effectiveness and efficiency is associated with Alternative 5 because of the effectiveness observed in the pilot study, while Alternative 4 contains the greatest amount of uncertainty since no pilot study data are available to evaluate the effectiveness of ISCO. Alternative 3 can be designed and implemented to address all contamination and has a great degree of flexibility to overcome unforeseen hydraulic capture issues or treatment requirements.

REDUCTION OF TOXICITY, MOBILITY OR VOLUME

Alternatives 3, 4, and 5 would reduce the toxicity, mobility, and volume of the VOCs through treatment. Alternative 5, which would introduce a temporary reducing environment during treatment of the source areas, would increase soluble metals concentrations in the short run. It is therefore ranked lower than Alternative 4, in which the oxidizing environment would temporarily decrease metals solubility. Alternative 3 is expected to reduce inorganics levels over the long term as source area groundwater containing Site-related metals contamination is withdrawn.

SHORT-TERM EFFECTIVENESS

Short-term risks to construction workers, surrounding communities, and the environment are expected to occur from the implementation of Alternatives 3, 4, and 5. Alternatives 3, 4, and 5 pose short-term impacts to the surrounding community due to increased vehicle traffic and noise from treatment, as well as an increased personnel presence in the area. Short term risks associated with Alternatives 3, 4, and 5 can be managed by a combination of Site controls, personal protective equipment (PPE), vapor and dust suppression and collection measures, and safe work procedures. Alternatives 3, 4, and 5 would all require coordination with the local government and existing businesses. Local impacts from the injections in Alternatives 4 and 5 are expected to be shorter term and easier to coordinate than the one to two year construction and testing of the two GET Systems and ongoing operation and maintenance (O&M). For Alternative 3, remedial workers would potentially be exposed to site-related contamination through dermal contact and inhalation of vapors during construction of extraction wells, remedy monitoring, and O&M of the treatment systems. Potential worker exposure for Alternatives 4 and 5 would be limited to injection well installations, injection activities, remedy monitoring, and, in the case of Alternative 4, pilot testing. Alternative 3 would take more than 30 years, Alternative 4 would take approximately 15 years, and Alternative 5 would take less than 10 years.

IMPLEMENTABILITY

All alternatives are technically and administratively feasible. Contractors, equipment, materials, and technical services are readily available for each alternative. Alternatives 3 would require aquifer testing to optimize extraction well placement, and startup testing, to ensure that the selected treatment train achieves the required discharge standards. Alternative 4 would require a pilot study to determine the actual radius of influence (ROI), oxidant, delivery rate, delivery pressure for the injections, and appropriate injection technology. Alternative 3 has a higher degree of constructability with the inclusion of two GET Systems and eight extraction wells, along with associated trenching and conveyance piping. The level of construction and infrastructure in Alternatives 4 and 5 is similar. It is anticipated that the potential risks for damaging existing infrastructure are greater with Alternative 3 than implementing Alternatives 4 or 5 because of the need to run conveyance piping, but this can be addressed through proper prelocation of existing utilities. Because of the number of injection points required for Alternatives 4 and 5, it is expected that more access agreements will be required for these options than for Alternative 3. However, Alternative 3 will require purchase of property or easements for the treatment buildings, extraction wells, conveyance piping, and utilities.

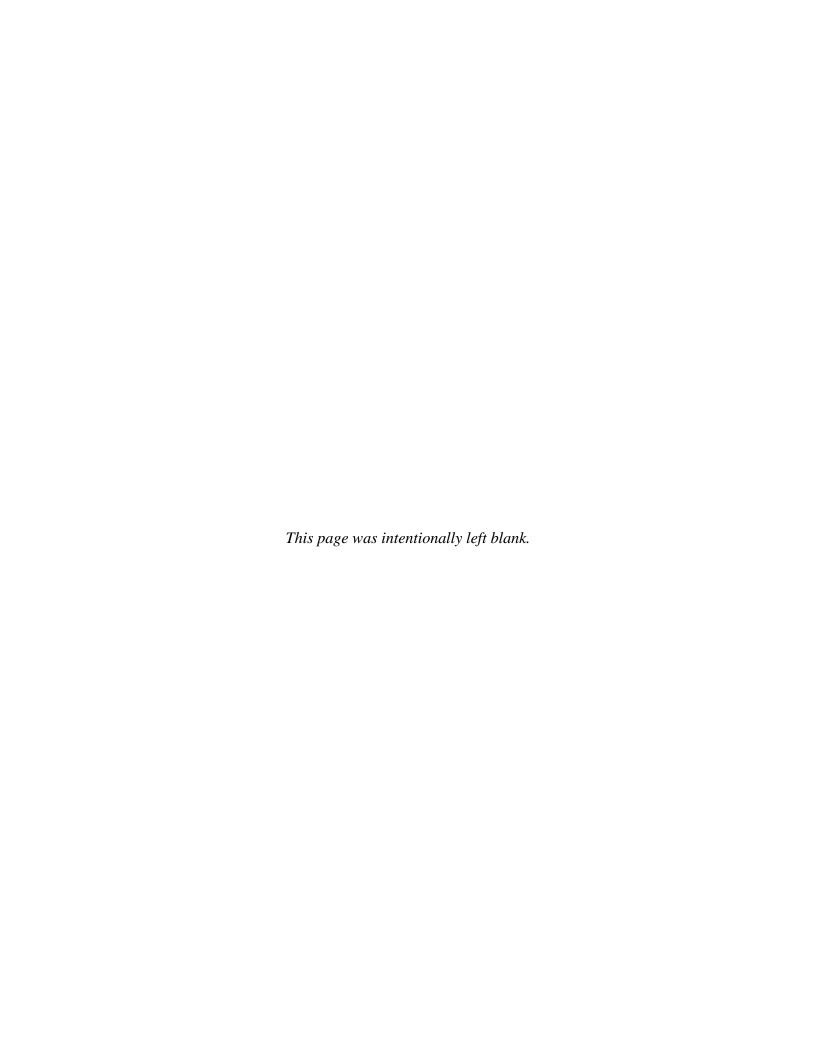
COST

The 30-year present value costs, assuming a discount rate of 7 percent stipulated by the EPA guidance (EPA, 2000), and the total costs escalated for inflation (assuming a yearly inflation rate of 1.5 percent) for all three alternatives are presented in tabular form below. The cost estimates included in this report are budgetary with an uncertainty of -30 percent to +50 percent.

	Alternative 3	Alternative 4	Alternative 5
Total Cost without Inflation	\$16,062,988	\$11,396,911	\$8,407,465
Total Cost with Inflation	\$18,446,014	\$11,717,063	\$8,539,690
30-Year Present Value Cost	\$10,640,511	\$9,786,359	\$7,467,690

STATE AND COMMUNITY ACCEPTANCE

The state and community acceptance criteria will be addressed during and following the issuance of the proposed plan and the subsequent public comment period.



FOCUSED FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 3 (OU3) NORTH PENN AREA 7 SUPERFUND SITE NORTH WALES, MONTGOMERY COUNTY, PENNSYLVANIA

1.0 INTRODUCTION

This Focused Feasibility Study (FFS) has been prepared for Operable Unit 3 (OU3) (groundwater) for the North Penn Area 7 Superfund Site (Site). This FFS has been conducted by HydroGeoLogic, Inc. (HGL) for the U.S. Environmental Protection Agency (EPA), Region 3, under Remedial Action Contract (RAC) EP-S3-07-05. This FFS has been prepared in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA). The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 Code of Federal Regulations [CFR] Part 300) establishes the framework for Feasibility Studies (FSs).

1.1 PURPOSE AND ORGANIZATION OF THE REPORT

The purpose of this FFS is to complete Steps 1 through 7 of the remedy selection process. State agency acceptance and public acceptance (Steps 8 and 9) must also be addressed before a remedy can be selected for the Record of Decision (ROD). Following the completion of the FFS process, EPA will select the preferred remedial alternative for OU3 of the Site and that will be presented in a ROD to provide a final groundwater remedy.

The purpose of this FFS Report is to develop, evaluate, and compare remedial alternatives that could be feasible for addressing potential risks to human health and the environment posed by contaminated groundwater at the Site. The scope of this FFS is based on discussions with EPA and information obtained from historical documents regarding site investigations.

This document has been prepared in accordance with the requirements of the NCP, 40 CFR Part 300, regulations for implementing CERCLA, as well as the guidance provided by the EPA in the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988). The FFS Report is organized as follows:

1.2 REPORT ORGANIZATION

This FFS Report is organized as follows:

- Section 1 provides introductory material and details the organization of the document.
- Section 2 provides an overview of the Site characteristics, history, and contamination, and identifies the potential contaminants of concern (COCs) for the Site.
- Section 3 includes a review of federal and state environmental regulations that must be considered when developing preliminary remedial goals (PRGs) and determining whether

the various possible remedies are appropriate for the North Penn 7 Site. To-be-considered (TBC) criteria, which include advisories, guidance, and proposed standards, are also included in this Section.

- Section 4 defines the remedial action objectives (RAOs) required to achieve protection of human health and the environment, identifies the PRG for each potential COC, and presents general response actions (GRAs) for achieving the RAOs.
- Section 5 estimates the areas and volumes of environmental media requiring remediation.
- Section 6 introduces and highlights available technology process options (TPOs) within each GRA. The TPOs are screened for potential use in developing a remedial approach for the Site. Appropriate technologies are retained for further analysis, and inappropriate ones are rejected.
- Section 7 combines the retained TPOs to form remedial alternatives, which are comprehensive sets of actions that may be used to achieve the RAOs.
- Section 8 provides an analysis of the remedial alternatives retained in Section 7.
- In Section 9, remedial alternatives retained for the detailed analysis are summarized and compared.
- In Section 10, remedial alternatives are compared to each other based on the evaluation criteria presented in Section 9 and the preferred alternative selected is discussed.
- Section 11 lists the references cited in preparing this FFS document.

2.0 SITE BACKGROUND

2.1 SITE LOCATION AND DESCRIPTION

The Site is located in North Wales, Montgomery County, Pennsylvania, and covers approximately 650 acres (Figure 2.1). The Site layout is illustrated on Figure 2.2. The Site consists of five former manufacturing facilities where solvents have been used as listed below:

- The 1.1-acre former Spra-Fin Incorporated (Spra-Fin) metal manufacturing and finishing business located on Wissahickon Avenue;
- The 36-acre former Ford Electronics and Refrigeration Corporation (FERCO) electronics and electrical auto parts manufacturing facility located at 1190 Church Road;
- The 23-acre former Teleflex Incorporated (Teleflex) facility located at 205 Church Road where mechanical, electrical, and pneumatic control devices were manufactured for the aircraft industry;
- The 50-acre former Leeds and Northrup Incorporated (Leeds and Northrup) electronic instruments manufacturing plant located at 351 Sumneytown Pike; and
- The 52.8-acre former Zenith Electronics Corporation (Zenith) television picture tube manufacturing facility located at 1180 Church Road.

For the purposes of remediation, EPA has divided the Site into four OUs, with OU1 and OU2 dealing with Site soil contamination. OU1 is the potentially responsible party (PRP)-led investigation and remedial action at four of the five former facilities: FERCO, Teleflex, Leeds, and Northrup, and Zenith properties. OU2 consists of a Superfund-led investigation and remedial action at the Spra-Fin property. OU3 consists of Site-wide groundwater contamination, and OU4 addresses vapor intrusion (VI) related to Site contaminants. This FFS addresses OU3.

2.2 SITE HISTORY AND PAST INVESTIGATIONS

Contamination was initially found at the North Penn 7 Site in 1979 by the North Penn Water Authority (NPWA) when trichloroethene (TCE) contamination was discovered in well L-22 (part of a well field with seven production wells). Two other wells in the production well field, L-17 and L-12, were sampled subsequently and also contained TCE. Wells L-17 and L-22 were left in operation to provide hydraulic control of the contaminant plume and help prevent further migration.

In 1986 EPA sent CERCLA 104(e) requests for information to facilities in the area, including Spra-Fin, Teleflex, Leeds and Northrup, and Zenith. Information was provided to EPA from these facilities over the next year. During this time, EPA also sent a CERCLA 104(e) request to FERCO and received their response.

The site discovery phase of the CERCLA process was completed in 1986 by NUS Corporation under an EPA contract. Based on the resulting Hazard Ranking System score, the Site was proposed for listing on the National Priorities List (NPL) in 1987. The Site was added to the NPL in 1989, with the five facilities listed above having been determined to be the primary sources of

groundwater contamination. A summary of each source area is provided below. More detailed information regarding the histories and past investigations for each of these five facilities include is included in the 2011 RI Report that was prepared for EPA (CDM, 2011).

2.3 TELEFLEX

Teleflex developed this property and operated a manufacturing facility for electronic, mechanical, and pneumatic control devices in 1956 and 1957. The Teleflex property consists of two buildings (Building 100 and Building 300) situated on 23 acres as shown in Appendix A. Outdoor wastewater treatment facilities were located adjacent to each building.

Throughout its operation, Teleflex used TCE and 1,1,1-trichloroethane (1,1,1-TCA) for cleaning metal parts in Building 100, the main building. Building 300 included a paint booth, although no chlorinated solvents were reported to have been used in the painting process. Based on past investigations, this facility is a potential soil source of TCE, 1,1,1-TCA, tetrachloroethene (PCE), and cis-1,2-dichloroethene (cis-1,2-DCE). Groundwater samples collected from overburden and shallow and intermediate bedrock wells for several years indicate that the highest concentrations of TCE were found within the vicinity of the Former Drum Storage Area, specifically from well T-7 (6,000 micrograms per liter $[\mu g/L]$).

2.4 ZENITH

The former Zenith property encompasses 52.8 acres and consisted of a 400,000- ft² manufacturing building and a smaller building with office and commercial space (see maps in Appendix A). An asphalt and concrete parking lot is located between the two buildings. Philco Corporation purchased the property in 1961 and in 1966 constructed the first building as a television picture tube manufacturing facility. Zenith purchased the property in 1973 and continued picture tube manufacturing activities for about 18 months, until December 1974 when the plant was closed. From 1966 through 1974, the former Zenith facility was reported to have used several thousand gallons of TCE each year. The TCE was delivered in drums, and waste TCE was reported to have been stored temporarily before being disposed of off site. Based on past investigations, this facility is a potential soil source of TCE, vinyl chloride, 1,2-dichloroethane, and cis-1,2-DCE. Groundwater samples contained up to 1.6 µg/L of TCE and 0.9 µg/L of 1,1,1-TCA.

2.5 FERCO

The property consists of about 36 acres located at the intersection of Church Road and Wissahickon Avenue. The property layout map is provided in Appendix A. Most of the land was at one time covered by buildings, asphalt, or concrete pavement. In 1993, all structures were demolished except Building 40-X, and some small ancillary structures. Beginning in 1947, the property was used for several manufacturing processes, and from 1994 to 1997 Building 40-X was the site of an electronics degreasing facility. The six degreasers housed in this building used TCE for cleaning electronic parts. Based on past investigations, this facility is a potential soil source of metals, volatile organic compounds (VOCs) (primarily TCE), and polychlorinated biphenyls (PCBs). Groundwater samples collected from one of the 500-ft deep bedrock production wells consistently contained TCE at levels between 250 μ g/L and 500 μ g/L, with a maximum detected concentration

of 1,000 μ g/L; 1,1,1-TCA had been detected in this well at 50 μ g/L (CH2M Hill, 1992). All production wells were abandoned by 2005.

2.6 LEEDS AND NORTHRUP

This property encompasses approximately 50-acres, and included a 643,000- $\rm ft^2$ manufacturing building and a 120,000- $\rm ft^2$ Technical Center (both are now demolished). Additional support buildings included a boiler house, an electrical substation, a metal salvage building, a hazardous waste storage building, and a flammable liquid storage building. In 1953, Leeds and Northrup developed the land for the manufacture of process control instruments. The Technical Center was built in 1950. Chlorinated solvents (mainly TCE and 1,1,1-TCA) were used in the manufacturing building as degreasing agents. Waste manifests indicate that, between 1981 and 1985, an average of 1,753 gallons of waste TCE was removed from the Site annually. Other documented solvent removals included: methylene chloride (55 gallons between 1985 and 1986), Freon (165 gallons between 1981 and 1985), and "unspecified solvent" (1,463 gallons between 1979 and 1980). Past investigations indicate this property is a potential soil source TCE, cis-1,2-DCE, 1,1-DCA, 1,1,1-TCA, and PCE. Groundwater samples collected from uncased borings contained up to 941 μ g/L of TCE, up to 323 μ g/L PCE, and up to 593 μ g/L 1,1,1-TCA.

2.7 SPRA-FIN

Spra-Fin began operations in 1963, using several production lines to paint metals and plastic parts for other manufacturers (CDM, 2003). The facility used a 100-gallon vapor degreasing unit with TCE as the primary degreasing solvent. In their CERCLA 104(e) response, Spra-Fin reported the purchase of 1,350 gallons of TCE in 1978 and 1,560 gallons in 1985. Other records indicate that Spra-Fin used 82 gallons of TCE per month (CDM, 1987). Other products purchased in 1986 included toluene (5 gallons) and xylene (1, 000 gallons), 15 gallons of black lacquer and 495 gallons of paint (CDM, 2011). Based on past investigations this site is a potential soil source of VOCs, primarily TCE. Groundwater samples collected from the borings near the old storage tank location had TCE concentrations of 262,150 μ g/L and 199,000 μ g/L. PCE and 1,1,1-TCA concentrations of 2,920 μ g/L and 3,670 μ g/L, respectively, were also reported for these locations. Four former production wells installed in bedrock are located on the Spra-Fin property. Samples from these wells have typically contained TCE at concentrations greater than 500 μ g/L. During a 1981 pumping test, the TCE concentration detected in samples from Spra-Fin Well No. 2 was 36,605 μ g/L. In March 1984, vinyl chloride was detected in one production well at 947 μ g/L (CH2M Hill, 1992).

2.8 ENVIRONMENTAL SETTING

The following Environmental Setting information is taken from the 2011 RI prepared by CDM.

2.8.1 Land Use and Zoning

The Site is surrounded by residential, commercial, and industrial properties. Two rail lines run through the Site in the north-south direction.

The Site is one of six NPL sites located within the NPWA service district. An estimated 91,000 people obtain drinking water from public and private wells within three miles of the Site.

2.8.2 Soils and Topography

Site topography consists of gently to moderately undulating hills, with the tops of ridges being moderately broad and with gentle slopes. Slopes may steepen in valley bottoms where surface water flows through streams. The elevation of the Site varies between approximately 430 ft above mean sea level (amsl) to approximately 280 ft amsl. The higher areas of the Site occur to the eastern boundary of the Site, and the lowest area occurs near the north-western boundary, at the Towamencin Creek.

Site soils are varied due to the size of the Site and the extensive development of the area. Generally, the Site is underlain by Chalfont silt loam, a subcategory to the Chalfont Series. This soil is characterized as very silty and with a slowly permeating subsurface layer which can restrict downward flow of water. The surface layer is a silt loam of up to 18 inches thick, and a reddish-brown shaley soil underlies the surface layer. Due to the lower permeability of the substratum, perching of water may occur during the wetter season of late fall to early spring.

Developed areas of the Site are classified as Made Land, with the subcategory shale and sandstone materials, sloping. This classification is very broad and applies to soils that have been disturbed, relocated, or removed from their original state, usually due to activities directly related to development of the land. The subcategory at the Site is associated with the mixing of weathered shale and sandstone materials in the soil. Characteristics of this soil vary widely, with moderate to low permeability, moderate to low water capacity, rapid to very slow runoff, a likelihood of severe erosion, medium to strongly acidic, and moderate to low fertility.

The soil overburden at the Site, as observed during the remedial investigation (RI), varied between 3 to 11 ft thick. An exception to this general overburden thickness was found at the Ford facility, where overburden thickness was up to 47 ft. This discrepancy is thought to be the result of the backfilling of a basement facility that once existed on the property.

2.8.3 Geologic Setting

The Site is located in the Triassic Lowlands of the Piedmont Physiographic Province. The Piedmont Physiographic Province covers southeastern Pennsylvania, except for the part of the Philadelphia area along the Delaware River, which is a part of the Coastal Plain Province. The Piedmont province is made up of three sections in this region: the Piedmont Upland, the Piedmont Lowland, and the Gettysburg-Newark Lowland. The sections are oriented from southeast to northwest.

The Piedmont Upland is composed of pre-Cambrian and Proterozoic-aged metamorphic rock. Rocks types of this section include high grade gneiss, schist, phyllite, and serpentenite. The dominant formation in the section is the Wissahickon Formation, made of a muscovite schist with localized zones bearing garnet.

The Piedmont Lowland is made of Cambro-Ordovician and Ordovician-age sedimentary and metasedimentary carbonates. The dominant formations in this section are the Ledger and Conestoga Formations. This section has a sedimentary shelf sequence which was deposited during Cambrian and Ordovician periods. These sedimentary units were then metamorphosed by tectonic activity.

The Gettysburg-Newark Lowland is made of Triassic-age mudstone, shale, and sandstone. The section often has a characteristic reddish brown color. The major formations in this section, from oldest to youngest, are the Stockton, Lockatong, and Brunswick formations. Together these formations represent the Newark group, and were deposited as lacustrine, fluvial, and alluvial sediments in the Newark rift basin.

Newark group units comprise the bedrock directly underlying the Site. Generally, the structure of the bedding planes in this group is characterized by a northeast/southwest strike, and between 5 to 20 degrees of dip toward the northwest. The Newark group in this area is an interfingered zone of contact between the Lockatong and Brunswick formations. This causes the bedrock at the surface to alternate, with three sections of Lockatong Formation separated by two sections of Brunswick Formation. The Lockatong Formation is a gray, argillaceous shale interbedded with thin beds of gray to black shale and siltstone. The Brunswick Formation is made of soft red shale, siltstone, and sandstone. Locally the orientation of bedding planes at the Site is northeast striking, with approximate dip of 11 degrees to the northwest.

Fractures and jointing occur here and enhance overall porosity of the formations. Within these joints and fractures, quartz and calcite commonly occur. There are three joint sets that have been reported in the vicinity of the Site. The most developed set strikes at approximately 30 degrees east (N30E). The other two sets strike at approximately N45W, and N75E. All three joint sets are reported to be nearly vertical, and are narrower and more widely spaced in the Lockatong Formation than in the Brunswick Formation. A dominant fracture pattern was documented during a fracture trace analysis performed for the Spra-Fin facility, showing fractures trending approximately north-northeast.

2.8.4 Hydrogeology

The Lockatong and Brunswick formations have little primary permeability, and as such almost all groundwater movement occurs through intersecting fracture sets. The well-developed, nearly vertical jointing occurring in the formations also are primary pathways for groundwater movement. It is believed that the intergranular porosity of the formation rock is too low to allow any significant movement of groundwater.

The Brunswick Formation has been extensively developed for groundwater supply through the Brunswick aquifer. This aquifer is strongly anisotropic, and hydraulic conductivity is greatest parallel to bedding strike. Supply wells capable of yielding tens to hundreds of gallons a minute have been completed throughout the formation, generally at depths of 200 to 500 ft. Groundwater in the Lockatong Formation yields an average of approximately 7 gallons per minute.

Potentiometric surfaces from the groundwater gauging event completed by HGL in July 2016 were developed for three bedrock zones based on the well screen elevations as follows:

- Upper Bedrock Zone wells screened above 270 ft amsl;
- Middle Bedrock Zone wells screened between 200 and 270 ft amsl; and
- Lower and Lowest Bedrock Zone wells screened below 200 ft amsl.

Groundwater elevation data and maps of the potentiometric surfaces that were developed from the elevation data are included in Figures 2.3, 2.4, and 2.5.

Groundwater flow in the upper bedrock zone generally flows to the south/southeast from the northwestern portion of the Site, to the southwest from the northeastern portion of the Site, and to the west from the eastern portion of the Site (Figure 2.3). A groundwater depression occurs around RI-03S. Groundwater flow in the Middle Bedrock Zone generally flows to the southwest (Figure 2.4). Groundwater flow in the Lower and Lowest Bedrock Zone generally flows in the same direction as the Upper Bedrock Zone with a groundwater depression observed around RI-09I (Figure 2.5).

2.9 TELEFLEX PILOT STUDY

A pilot study was conducted by HGL at the former Teleflex facility to determine whether in situ bioremediation using biostimulation is an appropriate alternative for OU3 groundwater. A summary of the study is presented below. Additional information can be found in the Teleflex Incorporated Property Pilot Study (HGL, 2016a).

The bioremediation pilot study was conducted from November 2012 through April 2016. Emulsified oil substrate (EOS) was selected for biodegradation of the site contaminants. EOS acts as a bio-stimulant, providing a food source for the naturally occurring microbial population found in the Site groundwater. Three wells (FS-1, FS-2, and FS-3) were installed for the purpose of completing injections and performance monitoring. One round of baseline groundwater sampling was conducted to establish pre-injection conditions. Two rounds of EOS injections were completed in December 2013 and October 2015). After the injections, four rounds of post-injection groundwater sampling were completed to monitor the performance of the injections.

Prior to the injections, 110 gallons of EOS was mixed for approximately 15 minutes with 400 gallons of potable water, 5 gallons of EOS CoBupHMg (buffer), and 32 ounces of EOS Vitamin B12 in a portable tote to fully mix the solution before it was injected into the well. The EOS was injected into FS-2 through a tremie pipe starting at a depth of 80 ft below ground surface (bgs) and ending at 30 ft bgs, injecting in 10-ft lifts. Injection pressures ranged from 5 pounds per square inch (psi) to 10 psi. After each of the EOS injections was completed, 200 gallons of potable water was injected into the well.

Two rounds of performance monitoring were completed after each of the injection events. Groundwater samples were analyzed for a combination of the following: VOCs (with difluorochloromethane), 1,4-dioxane, total and dissolved metals, nitrate, nitrite, sulfate, chloride, alkalinity, total organic carbon (TOC), dissolved hydrogen, dissolved gases (ethane, ethene, acetylene, and methane), volatile fatty acids (VFA), CENSUS®, and phospholipid fatty acids (PLFA).

Post-performance monitoring data indicated that the TCE concentrations decreased in the localized area around the injection well. Significant TCE decreases were seen in monitoring wells FS-2 (from 2300 μ g/L in February 2013 to 13 U in May 2015), MW-1T (from 2,000 μ g/L in February 2013 to 1,000 μ g/L in April/May 2016); in FS-1 (from 1,300 μ g/L in February 2013 to 50 U μ g/L in April/May 2016); and in FS-3 (from 220 μ g/L in February 2013 to 15 μ g/L in April/May 2016). FS-2 was sampled again in April/May 2016, but due to EOS from the second injection still present in the well, the detection limit for TCE was elevated at 1300 μ g/L. The remainder of the TCE plume did not appear to have been affected by the EOS injections, as the concentrations did not change significantly from the baseline sampling event.

Results from the pilot study indicate that EOS injection is a viable option for reducing the VOC concentrations in groundwater at the Site. The EOS injections were effective in decreasing the VOC levels within the injection well and surrounding performance monitoring wells. The radius of influence (ROI) of the injection appears to be between 25 ft and 40 ft based on the spacing of the wells sampled and the evaluation of the data. Elevated concentrations of TCE daughter products were seen in the injection well (FS-2) and wells FS-1 and FS-3, indicating that reductive dechlorination of TCE is occurring. While vinyl chloride was detected in only one sample, ethene concentrations increased in these three wells following the injections. This observation could be the result the detection limits for vinyl chloride being above the actual concentration values. Populations of Dehalococcoides did increase by a significant amount in wells FS-2, FS-1, and FS-3, indicating that the EOS had a positive effect on microbial populations in the site groundwater. The injections also helped change the groundwater to more reducing conditions in these same three wells. EOS was still present in the injection well 17 months after the initial injection. EOS was present in well FS-1 (25 ft from the injection well) five months after the first injection and absent six months after the second injection, indicating a longevity of less than 6 months within 25 ft of the injection well. Well FS-3 (30 ft from the injection well) did see positive results from the injection, but it is uncertain whether the EOS directly impacted the well (no significant TOC increases seen after injections), or if the changes in groundwater are attributable to the treated groundwater from the injection well flowing into FS-3.

2.10 2016 SITEWIDE GROUNDWATER SAMPLING

HGL conducted sitewide groundwater sampling in July/August 2016 to determine the current concentrations of contaminants across the Site. A summary of the sampling and results are presented in this section. Additional information can be found in the July/August 2016 Sitewide Groundwater Sampling Trip Report (HGL, 2016b).

A total of 29 monitoring wells and 2 NPWA production wells were sampled and analyzed for VOCs, metals, and 1,4-dioxane. No detections exceeded the maximum contaminant level (MCL) in the production wells. Twelve organic contaminants were identified in the monitoring well samples, though only 1,4-dioxane, carbon tetrachloride, cis-1,2-DCE, PCE, and TCE were detected at concentrations greater than their respective screening levels. Results are summarized below.

• 1,4-Dioxane. 1,4-dioxane was detected in 4 of 29 samples. The only detection that exceeded the Regional Screening Level (RSL) of 0.46 μ g/L was reported in RI-08S at 1.2 μ g/L.

- Carbon tetrachloride. Of the 29 samples collected, two exceeded the RSL of 0.46 μ g/L, but all were less than the MCL of 5 μ g/L.
- **cis-1,2-DCE.** Of the 29 samples collected, 19 had detections of cis-1,2-DCE, but only the detection of 56 μ g/L at RI-11I exceeded the RSL of 36 μ g/L. The RI-11I sample result did not exceed the MCL of 70 μ g/L.
- TCE. TCE was detected in 21 of 29 samples. All detected concentrations exceeded the RSL of 0.49 μg/L, but only five exceeded the MCL of 5 μg/L. TCE distribution is discussed below.
- **PCE.** Of 29 samples, 17 had detections of PCE, but only five exceeded the MCL of 5 µg/L. The highest PCE detections were found in samples collected near the former Ford facility. Additional discussion of PCE distribution is presented below.

TCE isoconcentrations contours were developed for the Upper Bedrock, Middle Bedrock, and Lower and Lowest Bedrock zones and are presented on Figures 2.6, 2.7, and 2.8, respectively. April/May 2016 TCE data collected as part of the Pilot Study completed at the former Teleflex facility have also been included on the figures. The highest TCE concentration of 1,000 μ g/L was in MW-1T on the former Teleflex facility in the Upper Bedrock zone. The only other Upper Bedrock wells that had TCE concentrations exceeding the MCL were RI-08S (8.8 μ g/L) and RI-08I (7.9 μ g/L). These wells are located just north of the former Northrup facility. TCE was detected above the MCL in the Middle Bedrock zone on the former Teleflex facility, with concentrations ranging from 13 μ g/L at MW-2 to 110 μ g/L at T-15 and to the north of the Former Spra-Fin facility in RI-11I, at 66 μ g/L. TCE was detected above the MCL in the Lower and Lowest Bedrock zone in wells RI-15D (26 μ g/L) and RI-15DD (16 μ g/L), which are located to the south of the former Zenith facility and west of the former Ford facility.

PCE isoconcentrations contours were developed for the Upper Bedrock, Middle Bedrock, and Lower and Lowest Bedrock zones and are presented on Figures 2.9, 2.10, and 2.11, respectively. April/May 2016 PCE data collected as part of the Pilot Study completed at the former Teleflex facility have also been included on the figures. Only two wells in the Upper Bedrock zone had detections that exceeded the PCE MCL of 5 μ g/L. These were in samples to the north of the former Spa Fin facility RI-11S (9.1 μ g/L) and RI-03S (6.1 μ g/L). In the Middle Bedrock zone, PCE was detected above its MCL on the former Teleflex facility, with concentrations ranging from 8.5 μ g/L at MW-2 to 78 μ g/L at RI-04I, and near the former Ford facility at RI-14I (33 μ g/L) and RI-03I (91 μ g/L). The only detection of PCE that exceeded the MCL in the Lower and Lowest Bedrock zone above MCL was to the southwest of the former Ford facility at RI-03D (26 μ g/L).

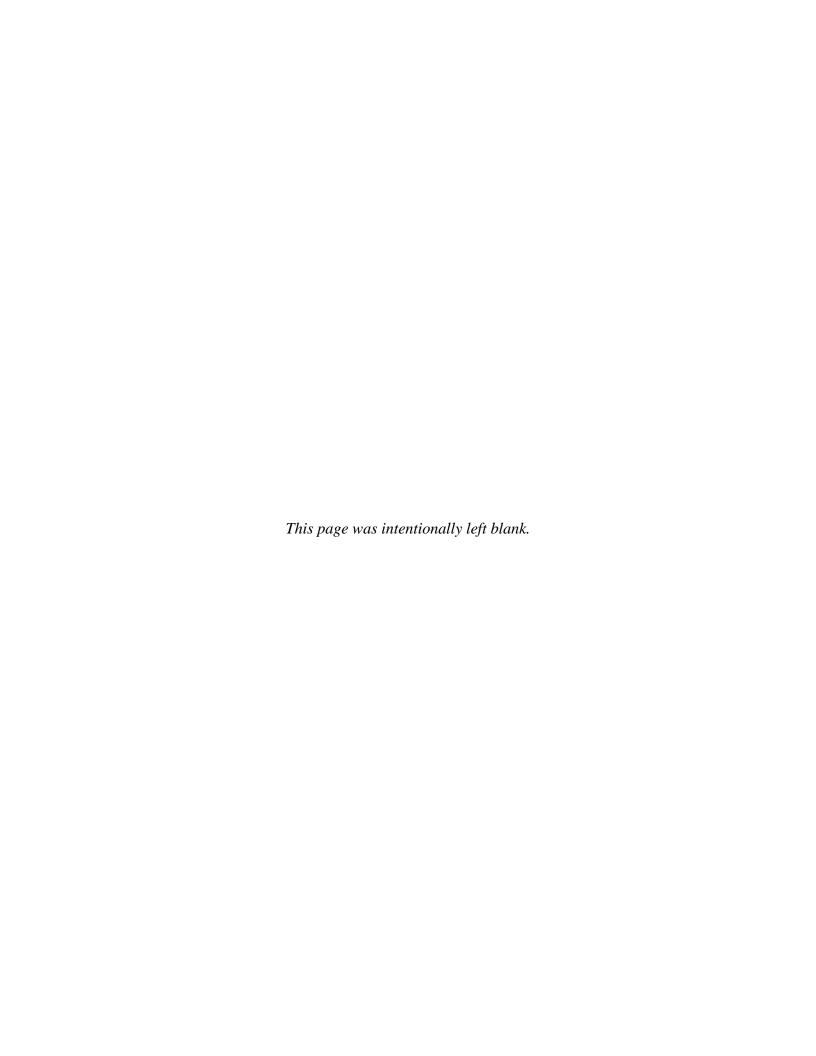
The only inorganic constituents detected in Site monitoring wells at levels that exceeded their respective MCLs or RSLs were arsenic and chromium. Results are summarized below:

• **Arsenic.** Of the 29 dissolved arsenic samples collected, 19 exceeded the arsenic RSL of 0.052 μg/L, but only 3 samples exceeded the MCL of 10 μg/L: RI-15D (11.9 μg/L), RI-05D (14 μg/L), and RI-14S (15.1 μg/L). Of the 29 total arsenic samples collected, 15 exceeded the arsenic RSL, but only 4 samples exceeded the MCL: RI-12D (11.2 μg/L), RI-15D (11.2 μg/L), RI-05D (14 μg/L), and RI-15DD (15.1 μg/L).

• Chromium. Total chromium was detected in 4 of 29 samples, with concentrations ranging from 1.6 μ g/L to 6.7 μ g/L. All four concentrations exceeded the RSL of 0.035 μ g/L, but were less than the MCL of 100 μ g/L. Dissolved chromium was reported as nondetect in all samples collected.

Arsenic isoconcentrations contours were developed for the Upper Bedrock, Middle Bedrock, and Lower and Lowest Bedrock zones and are presented on Figures 2.12, 2.13, and 2.14, respectively. April/May 2016 arsenic data collected as part of the Pilot Study completed at the former Teleflex facility have also been included on the figures. None of the wells exceeded the MCL in the Upper Bedrock zone. Only FS-2 exceeded the MCL in the Middle Bedrock zone on the former Teleflex property, with concentration of 15.5 μ g/L. As discussed in Section 2.9, FS-2 was injected with EOS and the elevated arsenic appears to have been caused by the change in the geochemisty of the groundwater. During the baseline sampling, arsenic was not detected in FS2. Arsenic was detected at concentrations exceeding the MCL in the Lower and Lowest bedrock zone in four wells at concentrations ranging from 11.2 μ g/L (RI-12D) to 15.1 μ g/L (RI-15DD). All of the exceedances were in the area of the former Zenith facility.

Analyses for VFAs, microbial population (PLFA and CENSUS), and methane were performed on samples collected during the sitewide sampling from wells RI-03S, RI-05S, RI-08S, RI-11S, and RI-13S to determine whether the groundwater chemistry was conducive to biodegradation. *Dehalococcoides*, which are identified in the CENSUS test, are bacteria that can reduce chlorinated ethenes to ethene. *Dehalococcoides* concentrations in the wells were very low, ranging from nondetect to 1.7 cells per milliliter. Although the populations are limited, these results are similar to concentrations seen in the Teleflex wells sampled before injections of EOS during the pilot study. After the EOS injections at the former Teleflex property, *Dehalococcoides* populations increased by multiple orders of magnitude, and biodegradation was seen within the injection well and surrounding wells. The VFA and PLFA data also are similar to those obtained for the Teleflex wells, indicating that the groundwater within these wells should react similarly to that found in the Teleflex wells.

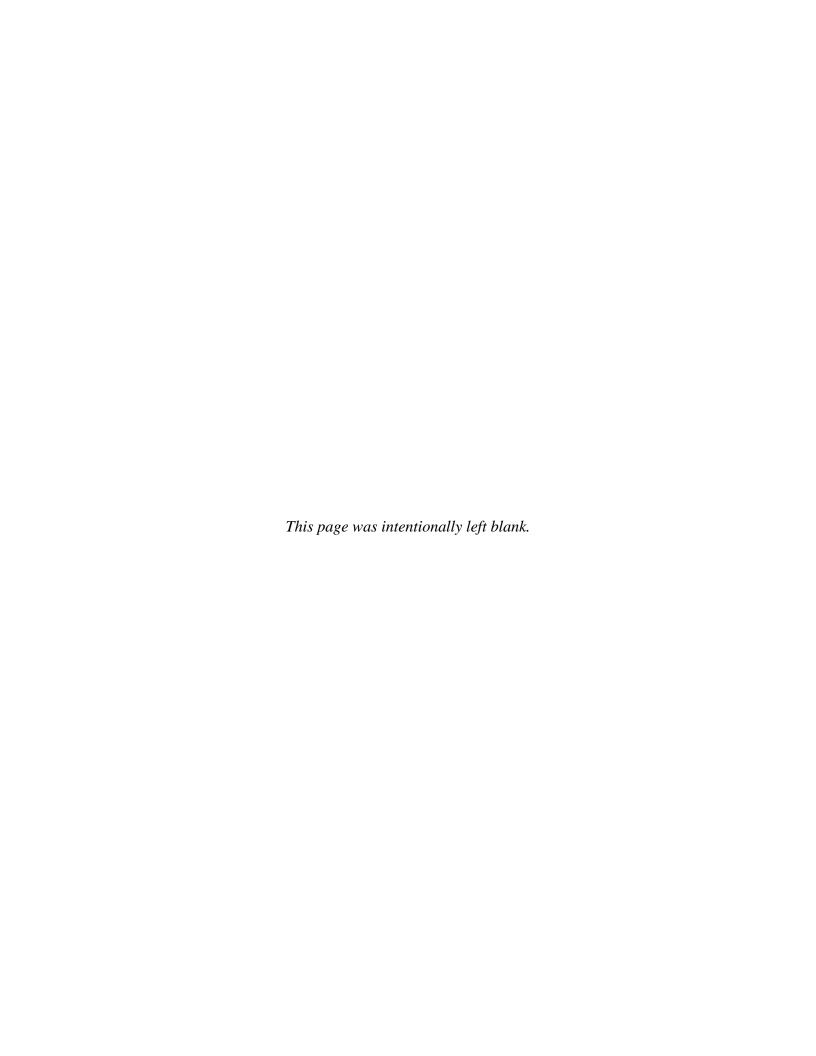


3.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

To meet the requirements of Section 121(d) of CERCLA, remedial actions must comply with state and federal Applicable or Relevant and Appropriate Requirements (ARARs) unless a waiver is justified. ARARs are used to help determine the appropriate extent of Site cleanup, to develop remedial action alternatives, and to govern the implementation of a selected response action.

In the absence of federal- or state-promulgated ARARs, or in the case where ARARs are judged to be inadequately protective, certain criteria, advisories, guidance values, and proposed standards may be used to develop remedial action alternatives or for defining PRGs. These criteria, advisories, guidance values, and proposed standards are identified by EPA as TBC criteria. TBC criteria are not legally binding and do not have the status of ARARs. EPA is authorized to modify PRGs to take into account TBCs, such as RSLs, in situations where attainment of the ARARs would still result in an excess cancer risk greater than 10^{-4} because of multiple contaminants or pathways (EPA, 1997).

Potential chemical-specific, location-specific, and action-specific ARARs for the Site, along with other TBC criteria, are summarized in Table 3.1. These ARARs and TBC criteria are considered potential because they are not finalized until the ROD is approved and issued.



4.0 CLEANUP GOALS

In this section, general RAOs are identified and developed into numerical site-specific PRGs.

4.1 REMEDIAL ACTION OBJECTIVES

CERCLA requires that selected remedial actions attain a degree of cleanup that ensures the protection of human health and the environment. The cleanup remedy must also be cost-effective and provide permanent solutions.

The only ecological exposure route identified at the Site was the groundwater discharge to surface water and wetlands in the form of potential seeps that were observed in the wetland adjacent to Towamencin Creek. This exposure route was evaluated in the OU1 Baseline Ecological Risk Assessment of Aquatic Habitats and determined that the wetland sediment poses a potential risk to terrestrial invertebrate/plant communities (CDM, 2012a). The chemicals determined to be potential ecological risks are not attributable to the groundwater contaminants and therefore will be addressed under OU1.

Any potential VI risk associated with groundwater will be addressed under OU4.

Based on the RI risk assessment, some Site contaminants occur at levels that pose possible risks to human health from potential exposure to groundwater. Therefore, the following RAOs related to restoration of Site groundwater and protection of human health were developed.

- Prevent exposure to Site-related groundwater contamination that would result in a target organ hazard index (HI) greater than 1 for non-carcinogens in the groundwater via the potential exposure routes of inhalation, ingestion and dermal absorption.
- Prevent exposure to Site-related carcinogens in groundwater at concentrations that would result in a cumulative cancer risk in excess of 1x10⁻⁴ (1E-04) via the potential exposure routes of inhalation, ingestion, and dermal contact.
- Meet the ARARs for the Site.
- Restore the contaminated groundwater to its beneficial use as a potable water supply.

4.2 CONTAMINANTS OF CONCERN

A list of risk drivers was identified in the 2012 human health risk assessment for OU3 (CDM, 2012b). These risk drivers were re-evaluated for this FFS to determine whether they should be retained as risk drivers. The revised list of risk drivers was identified using the following criteria:

- The chemical must be a Site-related contaminant.
- The chemical contributes a cancer risk greater than 1E-05 to a cumulative cancer risk greater than 1E-04 and/or the chemical contributes a non-hazard quotient greater than 0.1 to a target organ HI greater than 1.

If the target organ HI equals 1, there is no risk to that organ because the dose is equal to the reference dose, which is defined as the intake at which there is no adverse effect even for the most sensitive of receptors. Therefore, risk drivers were identified only if a target organ HI is greater than 1. The rationale for selection of the risk drivers is presented in Table 4.1. All cancer risks and non-cancer HIs were obtained from the Superfund Part D tables presented in the *Final Human Health Risk Assessment for OU3 Groundwater* (CDM, 2012b). The COCs identified in the *Final Human Health Risk Assessment for OU3 Groundwater* were:

- Antimony
- Arsenic
- Barium
- Chromium
- Cobalt
- Iron
- Lead
- Zinc
- PCE
- TCE
- Cis-1,2-DCE
- Vinyl chloride
- Carbon tetrachloride

The risk drivers consist of chlorinated VOCs and inorganics. Although PCE, TCE, and cis-1,2-DCE were identified as risk drivers, vinyl chloride is not present at high enough concentrations to pose an unacceptable risk. The presence of cis-1,2-DCE and vinyl chloride indicates that PCE and TCE are being reduced to their daughter products. Because of the potential for the vinyl chloride concentration to increase if the rate of cis-1,2-DCE reduction increases, vinyl chloride was identified as a COC even though it is not currently a risk driver.

Antimony, arsenic, barium, chromium, cobalt, iron, and zinc in groundwater are risk drivers, but based on the reasons listed below, these metals should not be identified as COCs warranting remedial action:

- Antimony: Antimony was detected only sporadically in the 2005 sampling event and was not detected in any wells during the 2006 or 2016 sampling events. Furthermore, antimony does not contribute to a target organ HI greater than 1 for the central tendency exposure (CTE) scenarios.
- Arsenic: The exposure point concentrations for this metal (per the 2012 OU3 HHRA) ranged from 5.4 μg/L to 9 μg/L. These concentrations are within the range of detections, 8.9 μg/L to 13.9 μg/L, reported for the deep background well. Arsenic was not detected in the shallow background well. The Site detections are similar to arsenic concentrations throughout the Newark Basin. Although there are not enough data to perform a statistical comparison, the available information suggests that arsenic in Site groundwater is naturally occurring and not a contaminant.

- Barium: Barium was identified as a risk driver for the north plume because it contributes a hazard quotient (HQ) of 0.2 to the kidney HI. Only one other risk driver, cis-1,2-DCE, affects the kidney. If the PRG for cis-1,2-DCE is calculated for a target HQ of 0.8 and is achieved, then remediation of barium is not necessary.
- Chromium: Chromium was identified because of its estimated cancer risk. Chromium is carcinogenic in its hexavalent from but is not a carcinogen in its trivalent form. Because groundwater samples were not speciated for chromium analysis, it was assumed that all chromium is in the hexavalent form. If chromium is primarily in its trivalent form, then it is unlikely to be a risk driver. If chromium is in the hexavalent form, then the anaerobic processes typically used to degrade PCE and TCE will also reduce chromium to its trivalent form. Additional speciation sampling for chromium should be conducted during the pre-Remedial Design (RD) phase to potentially eliminate chromium as a contaminant of concern.
- Cobalt: Cobalt was identified as a risk driver for the south plume under both the reasonable maximum exposure (RME) scenario and CTE scenario. Under the latter scenario, cobalt is a risk driver only because it partially contributes to an HI greater than 1 for the heart. Most of the heart HI is due to TCE. Once TCE is remediated, the CTE heart HI will not exceed 1 even if cobalt concentrations do not decrease. In addition, this metal's solubility can be affected by the changes in groundwater geochemistry associated with in situ degradation of chlorinated compounds. Once active remediation of the chlorinated compounds is complete and the groundwater returns to its natural geochemistry, it is likely that cobalt concentrations will return to their natural levels.
- Iron: The HHRA identified iron as a risk driver based on its contribution to HIs for blood and liver. According to Provisional Peer Reviewed Toxicity Values (PPRTV) for Iron and Compounds (EPA, 2006), the critical effect for derivation of the reference dose for this metal is gastrointestinal toxicity. If the target organ for iron is revised to be just the gastrointestinal tract, in accordance with the information in the PPRTV, then iron would not be identified as a risk driver. In addition, the CTE estimates do not identify iron as a risk driver.
- Zinc: This metal was identified as a risk driver for the child resident consuming water from well R27 because zinc contributed a HQ of 0.4 to a blood HI of 2. The blood HI was calculated from the HQs for antimony, iron, and zinc. As described above, the target organ for iron is the gastrointestinal tract, not blood. If iron's contribution is removed, then the resulting HI is 1.4, which does not exceed 1 to one significant figure. In addition, the CTE for well R27 shows no target organ HIs greater than 1.

The *Final Human Health Risk Assessment for OU3 Groundwater* (CDM, 2012b) evaluated potential exposure of the child resident to lead in water at residential well R27 and in the north plume (contamination north of Wissahickon Creek) through blood lead modeling. The assessment concluded that lead in groundwater at well R27 poses a health risk but lead in the north plume groundwater does not. Lead detections were not reported for the samples from background wells RI-06S/D. The exceedance of the MCL for lead in residential well R27 was only detected above the MCL in 1 of 3 sampling events (detected at 225 µg/L). The RI identified R27's usage as strictly irrigation (CDM, 2011). However, the HHRA used ingestion and showering/bathing in contaminated groundwater to calculate cancer risks (CDM, 2012a). Based on the uncertainty of well R27's usage, it is recommended that this well be re-sampled, and if lead still exceeds the

MCL, then remediation can be implemented with a point-of-use or whole home filtration system. Re-sampling should include sampling from the tap and sampling at the wellhead to determine if plumbing may be a source of lead. Lead is therefore included as a COC.

As described in Section 2.9, enhanced reductive dechlorination through injection of a carbon substrate amendment such as EOS was identified as a viable remedial technology for degradation of the chlorinated compounds. In situ chemical oxidation is another potentially viable technology for degradation of the chlorinated solvents. Both of these technologies affect the groundwater geochemistry, which can have secondary effects on metal concentrations. Once remediation of organics is complete and the remediation amendments have been consumed, it is expected that groundwater geochemistry will return to natural conditions, thereby allowing the metal concentrations to return to natural levels. Once these levels are achieved, groundwater sampling should be performed across the Site, and additional background wells should be sampled to provide a more robust set of background metals data. A revised risk assessment can then be performed to determine which, if any, metals pose a human health risk. If any are determined to contribute to an unacceptable human health risk, the data can be used to determine whether the residual metals concentrations exceed background levels through statistical analysis using ProUCL software. If additional background wells are needed to achieve a sufficient background data set, they can be installed as part of the RA implementation.

4.3 DETERMINATION OF REMEDIATION GOALS

4.3.1 Basis for Preliminary Remediation Goals

PRGs are risk-based or regulatory-based concentrations used as initial cleanup goals. PRGs are not the final cleanup standards. However, they are helpful in providing long-term targets to use during the analysis of different remedial alternatives. As part of the PRG development process for the Site, several information sources were considered. Each of these sources is discussed below.

4.3.1.1 National Primary Drinking Water Standards (MCLs)

MCLs are legally enforceable limits on the concentrations of various contaminants permitted to be present in tap water that is supplied by public water supply systems. Primary MCLs represent chemical-specific ARARs.

4.3.1.2 EPA Regional Screening Level Tables, November 2017

The EPA tap water RSL tables provide tap water concentrations that are associated with a cancer risk of 1E-06 and non-cancer hazard quotients of 1 for a standard resident exposure (Tap Water RSLs). In addition, these tables provide toxicological information that can be used in the development of PRGs to protect human health. RSLs are TBC criteria.

4.3.1.3 Risk-Based Calculations

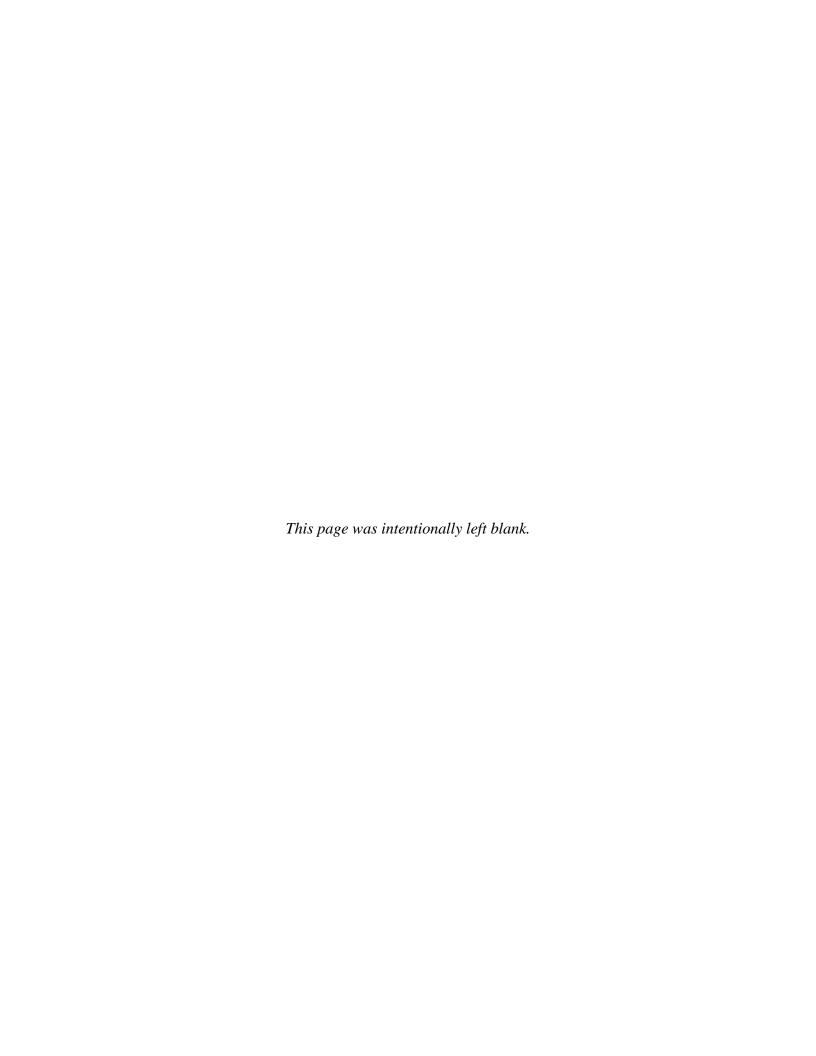
The equations used to estimate the risks associated with Site contaminants can also be used to calculate concentrations protective of human health.

4.3.2 Preliminary Remediation Goals

As indicated by the RAOs, the only medium requiring remediation is groundwater.

The groundwater PRGs are identified in Table 4.2. The PRGs were obtained from several sources in the following hierarchy:

- For those chemicals that have an MCL and were identified as a COC, the MCL was initially identified as the cleanup goal. The MCL was then evaluated to assess whether it represents a concentration that is protective of human health.
- For those COCs that do not have an MCL and those COCs with MCLs that are not protective, the cleanup goal was based on the tap water RSL (cancer risk = 1E-06, non-cancer HQ = 1) or risk calculations.



5.0 AREA AND VOLUME REQUIRING REMEDIATION

The area and volume of contamination requiring potential remedial action were determined based on the comparison COC concentrations to the PRGs. The only COCs detected above their PRGs are TCE, PCE, cis-1,2-DCE, arsenic, barium, cobalt, and lead.

Lead was detected above the PRG only in residential well R27. This well was sampled three times as part of the 2006 RI, and lead was only detected during the third sampling event at a concentration of $225 \,\mu\text{g/L}$. Due to the isolated detection and the lack of lead detections in the Site wells, R27 should be resampled to confirm if the lead exceedance was an isolated occurrence. In addition, one sample should be collected at the well head and one from within the residence to rule out any potential lead contamination coming from the residence piping. Should the lead concentrations still exceed the PRG and not be related to the pipes, remediation should be implemented with a point of use or whole home filtration system. Due to the isolated nature of the lead detection at R27, lead has not been evaluated for treatment or included in calculations for area and volume of the plume.

Barium and cobalt only exceeded PRGs in the injection well (FS2) on the former Teleflex property. The exceedances of barium and cobalt appear to have been caused by the change in the geochemisty of the groundwater from the injection of EOS. During the baseline sampling, neither barium nor cobalt were detected in FS2. Because these elevated metal concentrations were not due to a release and should return to background conditions after the EOS has degraded, these metals will not be evaluated for treatment or included in calculations for area and volume of the plume.

Total arsenic was detected above the PRG in five wells ranging in concentrations of 11.2 µg/L to 15.1 µg/L. Most the wells (RI-05D, RI-12D, RI-15D, and RI-15DD) are located in the northern portion of the Site by the former Zenith facility. FS2 on the former Teleflex property also had an elevated detection of arsenic, but as discussed in Section 2.10, this likely resulted from the EOS injection. The other exceedances are believed to be naturally occurring due to geochemical variations in the bedrock. There is no documented potential source of arsenic in this area. During the RI, two background wells (RI-06S and RI-06D) were sampled and analyzed for arsenic in 2006. Arsenic was not detected in the shallow well RI-06S, but was detected at a concentration of 12 µg/L in deep well RI-06D, exceeding the PRG. This data correlates well, as all the wells by the former Zenith facility with exceedances were also deep wells. In 2006, the U.S. Geological Survey (USGS) published a paper that included the study of arsenic concentrations within the Newark Basin (USGS, 2006). Between February 2004 and April 2005, USGS sampled 46 private drinking water wells and 12 monitoring wells. Fourteen had arsenic concentrations greater than the MCL with a maximum detection of 61 µg/L. The study also found a correlation between pH and elevated arsenic. All the private supply wells that had arsenic levels greater than the MCL had a pH of 8 or higher. The four wells at the Site that had arsenic concentrations that exceeded the MCL had an average pH of 8.15, while the rest of the monitoring wells sampled during 2016 had an average pH of 7.62. Because the elevated arsenic concentrations are comparable to the background wells on Site and similar to groundwater concentrations within the Newark Basin, arsenic will not be evaluated for treatment or included in calculations for area and volume of the plume.

TCE, PCE, and cis-1,2-DCE have been detected at concentrations exceeding PRGs across the Site. Figure 5.1 shows the wells where at least one VOC has been detected above PRGs. Because of

access issues, not all the wells sampled during the RI were sampled in 2016. As a result, there is no current data for those wells. The wells that were not sampled in 2016 but had detections exceeding PRGs during the 2006 RI sampling are also included on Figure 5.1.

Based on the 2016 sampling data, there has been a significant decrease in TCE concentrations in wells sampled in both 2016 and during the 2006 RI. Figure 5.2 presents the TCE data from the 2006 and 2016 sampling events in graphical form for wells sampled during both events. Of the 36 wells sampled during both events, 24 exceeded the PRG with 17 of the exceedances greater than 100 µg/L in 2006. In 2016, the same wells had only 9 exceedances of the PRG with only one well with a concentration greater than 100 µg/L. Figure 5.3 presents the PCE data from the 2006 and 2016 sampling events in graphical form for wells sampled during both events. The observed reduction in PCE concentrations was not as significant as that seen for TCE, but the 2016 PCE concentrations were lower than the TCE in 2006 with only 10 wells exceeding the PRG. Seven wells exceeded the PRG in the 2016 samples. The most significant reduction was in the well pair RI-11S/I where concentrations dropped from 200 µg/L in 2006 to less than 10 µg/L in 2016. PCE concentrations in wells RI-04I, RI-14I, RI-03I, RI-03D, and RI-03S increased from 2006 to 2016. Cis-1,2-DCE was detected above the PRG in wells R-22, RI-11S, RI-11I in 2006. Cis-1,2-DCE concentrations decreased in wells RI-11S and RI-11I during the 2016 sampling event to below the PRG. FS2 also had detections of cis-1,2-DCE during sampling associated with the Teleflex injections.

The estimated remediation boundaries (i.e. VOC concentrations exceeding PRGs) are presented on Figure 5.1. Based on the significant reduction of TCE seen since the RI was conducted in 2006, several areas within the estimated boundary might not require remediation if wells that were not sampled in 2016 are sampled and show lower concentrations than seen in 2006.

To calculate the volume of VOC contaminated groundwater that exceeds PRGs, the contamination was split into two plumes, northern and southern. The northern plume extends from the former Ford facility to the southwest past the former Teleflex facility. The southern plume extends from the northeast of the former Spra-Fin facility to the west/southwest by the former Leeds facility and former Northrup facility. The northern plume covers an area of approximately 2,750,000 ft² and a thickness of approximately 250 ft. Assuming an average porosity of 10 percent, the minimum volume of contaminated groundwater that is present would be approximately 514,000,000 gallons. The southern plume covers an area of approximately 3,700,000 ft² with a thickness of approximately 250 ft. Assuming an average porosity of 10 percent, the minimum volume of contaminated groundwater that is present would be approximately 692,000,000 gallons. Therefore, the total minimum volume of contaminated groundwater present at the site would be approximately 1,206,000,000 gallons.

6.0 IDENTIFICATION AND SCREENING OF TECHNOLOGY TYPES AND PROCESS OPTIONS

GRAs, and specific technology types and TPOs within each GRA type are defined in this section. The phrase "technology process options" refers to specific processes within each of the general technology types.

GRAs are introduced in Section 6.1. In Section 6.2, potential remedial technologies are identified within each of the GRAs, and the identified TPOs are screened based on technical feasibility at the Site. Only the TPOs that are feasible at the Site are discussed in detail. The TPOs that remain after the screening are summarized in Section 6.3. These remaining TPOs will be used in assembling remedial alternatives for the Site.

6.1 GENERAL RESPONSE ACTIONS

GRAs are medium-specific generic types of remedial actions that can, alone or in combination, achieve the RAOs established for the site. GRAs proposed for the site include:

- **No Action.** The No Action GRA implies that the site is left in its present condition. This response action provides a background against which all other remedies can be compared. Evaluation of the No Action alternative is required by the NCP.
- **Institutional Controls (ICs).** ICs may reduce human health risks from site contaminants by restricting land use or activities at the site.
- Containment. Containment refers to physical processes that would restrict contaminant mobility without changing their concentration or toxicity. Containment protects human health and minimizes ecological risk by controlling the routes of exposure.
- **Treatment.** Treatment may include any physical, chemical or biological processes that would lower human health or ecological risk from the contaminants by their destruction or conversion into less hazardous forms.
- **Removal.** Removal includes physically removing contaminated material as an initial step for treatment and/or disposal.
- **Disposal.** Disposal involves methods to discard contaminants, treatment by-products, and/or removed soils off site in accordance with all applicable regulations.
- **Monitoring.** Monitoring of site conditions provides useful information about remediation progress. In addition to visual inspection of installed remedial action (RA) measures, monitoring also includes sampling of soil, sediments, soil gas, groundwater, and surface water.

Applicable technologies associated with each of the above GRAs are discussed below. These technologies are typical of those used at sites with contaminant nature and extent similar to OU3.

6.2 IDENTIFICATION AND SCREENING OF TECHNOLOGY PROCESS OPTIONS

In this section, TPOs that could satisfy the RAOs and PRGs established above are identified and screened for applicability in the remediation of Site groundwater. Soil and soil gas remediation

technologies were omitted because, as indicated by the RAOs, neither of these media requires remediation.

For those technologies identified in the preliminary screening as not potentially effective, the rationale for this decision is included. Those technologies that have been identified as potentially effective are evaluated in greater detail based on their effectiveness, implementability, and cost. Based on this evaluation, the technology is either retained for further evaluation or eliminated. Each of the three criteria is briefly defined below:

- Effectiveness The ability of a technology to meet the defined RAOs.
- <u>Implementability</u> Technical and administrative feasibility of implementing the technology. TPOs that are not technically feasible at the site were eliminated during a pre-screening step. During this evaluation, the remaining TPOs are compared based on such considerations as the ability to meet the substantive provisions of permit requirements; the availability of treatment, storage, and disposal services; and the availability of necessary equipment and skilled workers to implement the technology.
- <u>Cost</u> A relative estimate of the cost of implementing the technology. This is based on engineering judgment and available reference sources. Costs are given as very low, low, moderate, or high relative to other process options.

6.2.1 No Action

The NCP requires that the no action alternative be used as a baseline against which to compare all other remedial technologies. The no-action option consists of leaving the Site as it is, without any remediation activities and only limited monitoring. Monitoring would be limited to what would be required for completion of Five-Year Review (FYR) Reports.

- <u>Effectiveness</u> This response would not be protective of human health or the environment. With No Action, no efforts would be taken to meet RAOs.
- <u>Implementability</u> No additional actions are required to implement this option, but this alternative is not likely to be approved by the public.
- Cost No costs are associated with the No Action alternative.
- <u>Recommendation</u> The NCP requires that the No Action alternative be used as a baseline against which to compare remedial alternatives. Therefore, the No Action alternative was **retained** for comparison purposes only.

6.2.2 Institutional Controls

ICs do not reduce contaminant toxicity, mobility, or mass. They do reduce or eliminate the potential for human exposure and can protect existing and future remedial measures. All proposed remedial alternatives include a form of ICs in combination with other treatment or containment methods. The proposed ICs are land use limitations attached to the Site through zoning ordinances, restrictive covenants, and access agreements.

Zoning Ordinances

The source areas and surrounding properties are zoned either industrial or light industrial. However, residential properties are located throughout the Site, with some residential properties adjacent to industrial and commercial properties including the source areas. As this FFS does not deal directly with VI issues, it is unlikely that recommending further zoning measures here would be useful in reducing the risk to human health from Site groundwater.

Restrictive Covenants

ICs may need to be put in place to prevent installation of new groundwater wells for potable use and to protect the groundwater monitoring wells at the property. Additional restrictions might be required to ensure that future construction activities do not disturb any remedial features that are built in the future.

Access Agreements

Access agreements will be required to ensure that sampling of monitoring wells can continue and operation and maintenance (O&M) of any on-Site treatment alternatives can be carried out. Air and soil gas monitoring, including measurements of contaminants adsorbed to airborne particles, may need to be conducted for some remedial alternatives to confirm that inhalation exposure risks for on-Site workers and others remain within the allowable human health criteria. Monitoring will also help in assessing the effectiveness of any selected remedial alternative.

- <u>Effectiveness</u> The effectiveness of restrictive covenants, access agreements and informational ICs would be dependent on the long-term commitment of the overseeing regulatory agencies. This action does not reduce the migration of contaminants to the groundwater, nor does it reduce the volume or mobility of contaminants in groundwater. This response action may be more effective in combination with other remedial options.
- <u>Implementability</u> Continued regulatory oversight would be required to maintain new ICs.
- <u>Cost</u> Costs associated with keeping the ICs in place by the regulatory agency are anticipated to be low.
- Recommendation ICs would control the exposure of potential receptors to contaminants but would be more effective when used in combination with other treatment options. Some ICs are currently in place at the site. Therefore, ICs were **retained** for further analysis.

6.2.3 Containment

Containment involves installation of physical barriers to prevent further migration of contaminants from groundwater to eliminate the potential routes of exposure. Containment could be achieved through vertical barriers and surface caps.

6.2.3.1 Vertical Barriers

Vertical barriers are usually constructed with a vertical trench excavated along the perimeter of the contamination. The trench is filled with bentonite slurry for support, and subsequently backfilled with a mixture of low-permeability material (1×10^{-6} cm/sec or lower). Such walls are keyed into an aquitard, a low-permeability soil or rock formation. Soil-bentonite slurry wall is most often used for vertical containment. Other vertical containment options include thin walls, deep soil mixing, grout walls, sheet pile walls and vertical liners.

6.2.3.2 Surface Caps

Surface caps can be constructed over the contaminated area to minimize exposure to contaminants in the groundwater, to prevent vertical infiltration of water into the capped area, and to contain contamination. Types of surface caps include evapotransporation, soil/clay, chemical sealant, multilayer, concrete, and asphalt. Typical construction costs for landfill caps range from approximately \$175,000 to \$225,000 per acre (FRTR, 2002). Based on the Turner Construction Index, the current estimated costs would be \$315,000 to \$405,000 per acre. While a surface cap would reduce the infiltration of precipitation at the Site, it would not prevent the horizontal migration of contaminated groundwater. When addressing groundwater contamination, surface caps are typically implemented in conjunction with, and tied into a vertical barrier.

- Effectiveness Containment using vertical barriers is unlikely to contain groundwater contamination due to the fractured bedrock located at the Site. A surface cap would be effective in minimizing exposure to contaminants in groundwater and would prevent vertical infiltration of water into the capped area, but it would not prevent lateral migration of the contaminants.
- <u>Implementability</u> Installation of a vertical barrier 250 ft into bedrock is not feasible given today's technologies. Installing a surface cap would be very difficult to implement, due to the existing infrastructure located on the Site (e.g. buildings, roads, parking lots). Finding space to install a vertical barrier or surface cap would not be feasible in such a developed area.
- <u>Cost</u> Costs for installation of a vertical barrier and surface cap would be extremely high because of the large area of the Site and the elevated costs that would be incurred to work around existing infrastructure.
- Recommendation The fact that groundwater, and the associated contaminants, are primarily in the bedrock to depths of 250 ft bgs, precludes the effective use of a vertical barrier. The inability of surface caps to control lateral migration and the difficulty of installing a cap at the Site make that approach impractical for this situation. As a result, surface caps and vertical barriers were **eliminated** from further consideration in this screening.

6.2.4 Removal

Removal cannot be considered a stand-alone remedial option for the Site but instead must be incorporated into any technology that includes ex situ treatment or disposal of the contaminated

material. Removal of contaminated material would entail extraction of contaminated groundwater. The extraction of groundwater is discussed in Section 6.2.5.2 in conjunction with treatment.

6.2.5 Treatment

Ex situ treatment requires the removal of the contaminated material from the subsurface before treatment can be accomplished.

In situ technologies treat contamination without removing it from the ground. Many of these technologies involve the addition of heat, air, or various substances to the vadose zone and/or saturated zone to enhance biological, chemical, or physical treatment processes. Because the Site groundwater is present in the fractured bedrock aquifer, it would be difficult to deliver treatment amendments to the entire contaminated area. However, local injection of the substances into areas with high groundwater contaminant concentrations can be used to remove some contamination and help achieve the Site RAOs.

6.2.5.1 Bedrock Fracturing

While not a removal or treatment technology in and of itself, fracturing can be used to increase the recovery of groundwater extraction pumping wells or improve the distribution of treatment additives. In hydrofracturing, pressurized water is injected into consolidated or impermeable material to fracture and increase its permeability. A slurry composed of a coarse-grained sand and guar gum gel or a similar degradable viscous fluid is then injected as the fracture grows outward from the injection point. After pumping is completed, the sand/gel mixture holds the fracture open while an enzyme additive breaks down the viscous fluid. The thinned fluid is pumped from the fracture, forming a permeable subsurface channel better suited for delivery of treatment agents or recovery of vapor-phase or liquid-phase contaminants (FRTR, 2002). Pneumatic fracturing is a similar process except that it involves injecting high pressure bursts of air into the area to be fractured. Pneumatic fracturing is used more frequently in bedrock than in unconsolidated materials because the bedrock fractures will likely remain open without the structural support that sand provides when hydrofracturing is performed. Conversely, pneumatic fractures created in clays or other low permeability overburden might close without the structural sand support (ITRC, 2005).

- <u>Effectiveness</u> The technology might improve the distribution and/or increase injection rates for in-situ treatment within the bedrock of the Site. The technology is has also shown to improve yield of extraction wells within bedrock.
- <u>Implementability</u> Bedrock fracturing would be easily implemented using the existing open-hole monitoring wells or newly installed open-hole wells. This technology could not be implemented within the existing Site wells that have been completed with PVC well screens.
- <u>Cost</u> Costs related to bedrock fracturing would be low, with estimation to be \$1,000 to \$1,500, based on creating four to six fractures per day (FRTR, 2002), consisting primarily of costs related to labor and subcontractor costs. Based on the Turner Construction Index, the current estimated costs would be \$1,800 to \$2,700.

• Recommendation – Although bedrock fracturing would not be an effective stand-alone remedy for the Site, it could be used in conjunction with in situ treatment, or for improving the yield of extraction wells associated with a groundwater extraction and treatment system (GETS). For this reason, bedrock fracturing has been **retained** for further consideration.

6.2.5.2 Groundwater Extraction and Treatment

Typical GETSs extract contaminated groundwater from the saturated zone and treat the extracted water using processes such as precipitation/coagulation/flocculation; filtration; ion exchange; green sand filtration; aerobic or anaerobic biological treatment; carbon adsorption; air stripping, and/or other treatment processes. These systems are used to contain the contaminant plume and to treat the extracted contaminated water. Groundwater extract and treatment is one of the most commonly used remediation technologies at contaminated groundwater sites (EPA, 2013).

GETSs pump groundwater from the ground using submersible pumps placed in extraction wells or in the sumps of groundwater collection trenches. Extracted groundwater is then conveyed to a treatment system located at the site. After the groundwater passes through the treatment train, it is discharged to a nearby surface water body or injected back into the ground. Permits (or permit equivalences) are likely to be required for surface water discharge or re-injection of the treated water. In some cases the extracted water is routed to a sewer for treatment in a local publicly owned treatment works. Regardless of the treatment technologies employed, a power source must be available at the Site for operation of pumps and other equipment. Groundwater monitoring and treatment system sampling are also required to monitor the performance of the GETSs. Because many contaminant plumes can involve substantial volumes of water and because containment must be maintained until the groundwater cleanup goals are achieved and maintained, GETSs typically operate for long periods of time. Consequently, costs related to O&M, system repairs, and remedy monitoring can add a substantial amount to the potentially significant capital costs of these systems (FRTR, 2002).

- <u>Effectiveness</u> Groundwater extraction could hydraulically contain the contaminant plumes and treat the VOC contamination, but the remediation time frame could be very long. Due to the size of the contaminated areas and the nature of the fractured bedrock at the Site, a large extraction well network with multiple treatment systems likely would be needed to optimize the remedy effectiveness.
- Implementability A GETS is a well-established technology and could be implemented at the Site. Land for the treatment building(s) will need to be bought or leased for the duration of the operation of the system(s). Numerous extraction wells and a substantial amount of conveyance piping and control wiring would be required to address the entire area of contamination. In addition, it is likely that more than one GETS would be needed to address the two separate plumes. This will require site access to areas on private property. To address data additional aquifer testing would be required to optimize the extraction well placement and system design.
- <u>Cost</u> Initial capital costs would be high to build the treatment system(s) and install the extraction wells. Major ongoing costs associated with a GETS include electricity, O&M

labor and materials, sampling and analytical services, and carbon replacement and regeneration.

• <u>Recommendation</u> – Groundwater extraction and treatment is a proven technology for VOC treatment from large groundwater plumes. Although the cost for implementing the technology would be high, the technology has been **retained** for further evaluation.

6.2.5.3 Monitored Natural Attenuation

In monitored natural attenuation (MNA), groundwater contaminants are naturally depleted over time by volatilization (from the groundwater surface and vadose zone), dilution and dispersion (in the saturated zone), adsorption to soil, and biodegradation. Natural attenuation processes can require extended periods of time to achieve sufficient removal of contaminants. The cost to implement this alternative is low and includes continued monitoring of groundwater quality.

As discussed in Section 5, TCE concentrations significantly decreased over a ten-year period without any active remediation (other than the pilot test at the former Teleflex Site). Even through the natural groundwater conditions at the Site indicate MNA may be effective for TCE, PCE was still found at concentrations exceeding PRGs and the concentrations did not decrease as significantly as the TCE. MNA should only be considered in plume areas where data indicate that decreasing concentration trends are occurring naturally, and concentrations are generally low, suggesting that PRGs can be met within a reasonable time frame. MNA can also be used as a follow-on remedy to another treatment such as in situ chemical oxidation (ISCO) or enhanced in situ bioremediation (EISB). Any decision to employ MNA should be backed by additional hydrogeologic investigation (determination of flow paths, contaminant migration rates) and an analysis of contaminant degradation rates that demonstrate that the plume is stable or shrinking and concentrations are declining.

- <u>Effectiveness</u> Current site conditions indicate TCE has reduced in concentrations to below PRGs without any remediation in several areas of the Site. It is expected that similar trends would be seen over time. Although PCE has not degraded as quickly as the TCE, it is expected that the distal portions of the plumes will be susceptible to MNA over a reasonable period of time.
- <u>Implementability</u> MNA is easily implemented but would require continued monitoring of groundwater quality. Site characterization required for MNA can be complex and costly. Determination of the flow paths, rates of contaminant migration, and rates of attenuation processes, is necessary to understand the current behavior and stability of the plume, and to predict the future behavior of the plume with an acceptable degree of certainty.
- <u>Cost</u> Costs related to the implementation of MNA would be low to moderate, consisting primarily of those charges related to labor, supplies, equipment rental, and analytical services necessary to complete the periodic monitoring of the groundwater determination of flow regimes, and modeling to predict future plume behavior.
- Recommendation Although MNA would not be an effective stand-alone remedy for the Site, it could be employed in areas of the plumes where decreasing lower concentrations

have been observed and/or as a follow-on remedy to be used in conjunction with ISCO or EISB. For this reason, MNA has been **retained** for further consideration.

6.2.5.4 Enhanced In Situ Bioremediation

Bioremediation is a process in which microorganisms degrade organic contaminants found in soil and/or groundwater, converting them to less toxic or innocuous end products. Aerobic bioremediation takes place in the presence of oxygen, and anaerobic bioremediation takes place in the absence of oxygen.

Natural bioremediation relies on indigenous microorganisms under existing Site conditions and is likely to occur to some extent regardless of what remedial technology is employed. EISB is a process in which site conditions are modified to enhance the desired microbial activity. Addition of nutrients (biostimulation), oxygen (bioventing), or other amendments (lactic acid, edible oil substrates, oxygen releasing compounds, etc.) can be used to enhance bioremediation. Acclimated microorganisms also can be added to the system (bioaugmentation). Solutions such as surfactants can be utilized to enhance desorption of the target compounds to increase their availability for microbial degradation. The remedial time frame for this technology depends on the available microbial community and the target contaminants (FRTR, 2002).

Based on the data gathered from the EOS pilot study, degradation of TCE is occurring and the groundwater has changed to anaerobic conditions in the vicinity of the injections at the former Teleflex property.

- <u>Effectiveness</u> The results from the pilot study indicate that EISB was successful at reducing TCE concentrations within the injection wells and in nearby wells. The ROI of the injection appears to be between 25 and 40 ft. EOS was still present in the injection well 17 months after the injection, indicating the EOS will still be viable for an extended time after injection. Additional amendment injections, and possibly bioaugmentation to introduce *Dehalococcoides*, would be needed in other portions of the Site to achieve complete remediation of the groundwater plume.
- <u>Implementability</u> Because of the relatively small ROI observed during the pilot study, additional injection wells would be needed for full treatment of the Site. Assuming an average of ROI of 30 ft, treatment of the entire area of the two plumes identified in Section 5.0 would require over 2,100 injection points. Given the developed nature of the Site, this approach is not feasible. However, EISB could be used to address the areas of highest contamination within the plumes. Injection wells would be required, and additional monitoring wells would be needed to monitor the progress of the remedy. The addition of *Dehalococcoides* into the Site groundwater may improve the treatment of VOCs.
- Cost Enhanced bioremediation is moderately inexpensive if carried out in situ, generally ranging from \$1,325 to \$1,825 per 10,000 gallons (Mazzarese, 2014). The EOS injections conducted during the pilot study did not benefit from economies of scale and cost approximately \$60,000 (\$3,473 per 10,000 gallons). The cost of *Dehalococcoides*, which would be employed at a rate of about one liter per injection point if bioaugmentation is used, is approximately \$275 per liter. Total costs would vary based on the number of injection wells needed, type of amendment, amount of amendment being used, method of injection, and level of performance monitoring.

• Recommendation – Because of its moderate cost and potential applicability at the Site, EISB was **retained** for further evaluation, but it will have to be used in conjunction with another treatment or removal technology, as the required number of injection points would be infeasible and cost prohibitive to use across the entire Site.

6.2.5.5 In Situ Chemical Oxidation

ISCO typically involves the introduction of an oxidant via injection into contaminated water to initiate an oxidation (redox) reaction. Oxidation reactions chemically convert hazardous contaminants to nonhazardous or less toxic compounds and elements through the transfer of electrons from the contaminant to the oxidant. As a result, the organic contaminant is broken down, leaving water, carbon dioxide, chlorides (in the case of chlorinated compounds), and other less toxic chemicals as the end products of the reaction. When using ISCO, most oxidants are injected into the subsurface as a solution, although ozone is injected as a gas. Oxidants that are commonly used include hydrogen peroxide, potassium permanganate, sodium permanganate, sodium persulfate, and ozone. In some cases, catalysts (such as iron in hydrogen peroxide reactions) are added to optimize the reaction.

The primary benefits to ISCO are its moderate cost, relatively short treatment time, and the fact that the contaminants are destroyed or, in the case of metals such as iron and manganese, made insoluble. Potential drawbacks for this technology include the fact that the oxidant does not last long in the groundwater. This could result in a need for multiple injections in some locations to address contaminant rebound (EPA, 2006).

- <u>Effectiveness</u> ISCO can effectively treat VOC contamination in groundwater directly, but concentrations may rebound. This would require multiple injection events in the same areas over time. It is anticipated that an ROI similar to that seen in the EISB pilot study would be achieved using an oxidant amendment.
- <u>Implementability</u> As is the case for EISB, additional injection wells would be needed for full treatment of the Site. Assuming an average of ROI of 30 ft, treatment of the entire area of the two plumes identified in Section 5.0 would require over 2,100 injection points. Given the developed nature of the Site, this approach is not feasible. ISCO could be used in the areas of highest contamination within the plumes. To achieve complete treatment of the groundwater plume, multiple injections likely would be necessary and additional injection points might be required. Additional monitoring wells would aid in monitoring the progress of the remedy.
- Cost Costs for ISCO are variable depending on treatment area and contaminant characteristics, generally ranging from \$2,250 to \$3,650 per 10,000 gallons (Mazzarese, 2014). When determining the costs and feasibility of employing oxidation for a particular case, various parameters must be taken into account including:
 - Kinetic rate of reaction:
 - Unit cost of oxidant;
 - Application method requirements;
 - o Hazardous material handling requirements;
 - o Required quantity of the oxidant;
 - Site geology and hydrogeology;

- o Soil and groundwater pH;
- o Abundance of naturally occurring organic matter in the treatment area;
- o Quantity of sorbed contaminants;
- Need for multiple applications to achieve PRGs; and
- Accessibility to the contaminated area.

A major injection cost difference to implement ISCO versus EISB would be the likely need for multiple injections as an oxidant does not remain active in the ground as long as a bioremediation amendment. Additionally, a pilot test would be needed to determine the most effective oxidant-catalyst mixture and the required application rate. Costs would vary based on the number of injection wells needed, type of amendment, amount of amendment being used, method of injection, and amount of performance monitoring.

• Recommendation – Because of its moderate cost and potential applicability at this site, ISCO was **retained** for further evaluation. If employed, ISCO would have to be used with one or more other treatment and/or removal technologies to ensure complete remediation of the entire Site as the required number of injection points would be infeasible and make the technology cost prohibitive to use across the Site.

6.2.5.6 Air Sparging/Soil Vapor Extraction

Soil vapor extraction (SVE) involves the application of vacuum to contaminated soils to extract volatile and some semivolatile organic compounds in a gaseous form from vadose zone soils. SVE can be combined with air sparging (AS) to address groundwater contamination. In AS, air or oxygen is injected down the well bores or through trenches installed below the groundwater table, aerating groundwater and mobilizing contaminants to the vapor phase for extraction.

Using AS/SVE to treat groundwater in the fractured bedrock aquifer will likely result in short-circuiting and poor treatment and would be very costly to implement over a large area. Capital costs (e.g., mobilization, recovery wells, blower, compressor and off-gas treatment train) may also be expensive relative to other technologies that have shown promise at the Site. As a result, AS/SVE was **eliminated** from further consideration in this screening.

6.2.5.7 In Situ Thermal Desorption

In the in situ thermal desorption (ISTD), the soil and groundwater are heated to temperatures above the boiling points of the contaminants, enhancing volatilization, and in some cases destruction, of VOCs. An SVE system is then used to collect the vaporized VOCs so that they can be treated. Heating of the contaminated matrices can be achieved by several methods, including hot air or steam injection, radio-frequency heating, electrical resistance heating, and thermal conduction heating.

Regardless of the technology selected to heat the subsurface, pilot testing would be necessary to determine electrode/well spacing and whether ISTD would be effective in dealing with the Site's bedrock contamination. The fact that contamination is in fractured bedrock in a developed area makes it unlikely that the technology could be effectively implemented in this situation. Also, this technology would be extremely costly to implement over a large area. Based on these factors, together with high expected costs of implementation, ISTD has been **eliminated** from further consideration in this screening.

6.2.5.8 Permeable Reactive Barrier

Permeable reactive barriers (PRBs) are installed across the flow path of a contaminant plume. Because they are built to be more permeable than the surrounding geology, PRBs treat or capture the contaminants while allowing the treated water to pass. PRBs can be constructed using zero-valent metals, chelators (ligands selected for their specificity for a given metal), sorbents, microbes, or other treatment media (FRTR, 2002). PRBs have been used to remediate both organic and inorganic contaminants.

PRB systems are extremely difficult to implement in situations where the impacted groundwater is in fractured bedrock. This is because of difficulties predicting contaminant flow direction and construction difficulties in bedrock geology. As a result, PRB technology was **eliminated** from further consideration in this screening.

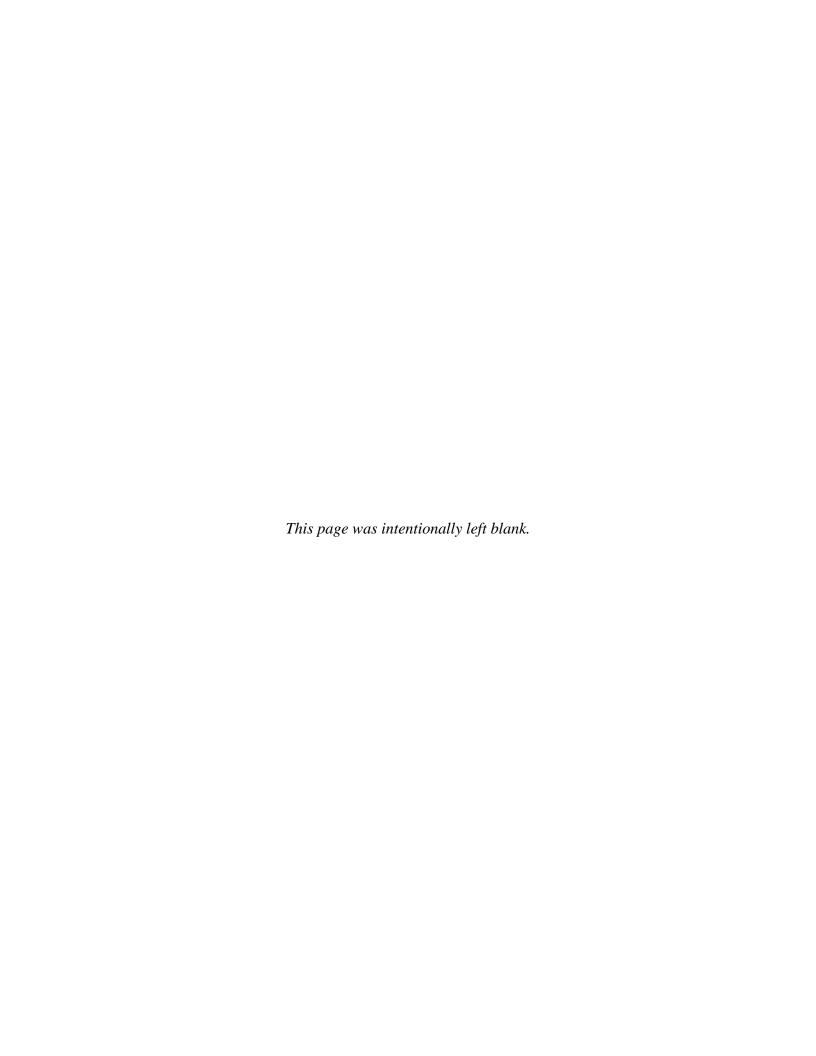
6.2.6 Disposal

While not applicable as a remedy by itself, disposal is a required component of some treatment remedies and most remedies that include a removal component. Possible disposal technologies include landfilling and incineration. Any landfilling or incineration of treatment residues (e.g., bag filters, spent carbon, tank bottom sludge) or excavated materials would be included in this category. Wastes that are being sent to a landfill must meet certain "land ban" requirements (e.g., pass a toxicity characteristic leaching potential test, no liquids), and some wastes must only be sent to hazardous waste landfills. Similarly, not all incinerators may handle all types of hazardous wastes. Disposal is **retained** for further consideration in this screening.

6.3 SUMMARY OF RETAINED TPOs

Based on the analyses presented above, the following TPOs were retained for possible inclusion in the remedial alternatives:

- No Action:
- ICs including deed restrictions and access agreements;
- Bedrock fracturing;
- Groundwater extraction and treatment;
- MNA:
- EISB:
- ISCO; and
- Disposal.



7.0 DEFINITION OF REMEDIAL ALTERNATIVES

The retained TPOs have been assembled into remedial alternatives that could potentially meet the PRGs for the Site. The remedial alternatives include a "No Action" alternative, as required by the NCP, as well as combinations of various removal and treatment processes. ICs to prevent the use of affected groundwater and allow access to properties for groundwater monitoring and necessary O&M activities are included as part of all alternatives. The proposed alternatives are discussed below.

7.1 ALTERNATIVE 1: NO ADDITIONAL ACTION

This alternative is required by the NCP and CERCLA. Alternative 1 requires no remedial action to be taken at the Site. The No Action alternative serves as a basis against which the effectiveness of all the other proposed alternatives can be compared. Under this alternative, the Site would remain in its present condition, and groundwater would be subject to natural processes only. FYRs of the Site, required under CERCLA, would consist of at least a Site visit and report preparation. No monitoring, other than that required for the FYR, will take place to assess any changes in site conditions. Costs associated with the No Action alternative would be very low.

7.2 ALTERNATIVE 2: MONITORED NATURAL ATTENUATION

Alternative 2 includes the aforementioned ICs. MNA is incorporated to address the groundwater contamination.

Annual sampling and groundwater elevation checks of groundwater monitoring wells would be performed and contaminant trends would be monitored. Groundwater modeling could be used to predict time required to achieve PRGs and determine whether a more active approach is called for. Additional monitoring wells might be needed to close current data gaps. Reporting on Site conditions would continue until the PRGs are achieved. The costs associated with MNA are those related to activities listed above.

7.3 ALTERNATIVE 3: GROUNDWATER EXTRACTION AND TREATMENT WITH MONITORED NATURAL ATTENUATION

Alternative 3 includes the aforementioned ICs, GETS operation, and MNA to address the groundwater contamination.

GETSs would be constructed to treat groundwater from the two contaminant plumes. Because of the distance between the two plumes and the fact that the Wissahickon Creek lies between the northern and southern plumes, it is likely that two separate GETSs would be installed. Air stripping with treatment of stripper off-gas using vapor-phase granular activated carbon is an effective method of removing VOC contamination from Site groundwater. Extraction wells screened at various depths would be installed within the plume boundaries based on the contaminant concentrations. Because GETSs require electrical wiring, control wiring, and conveyance piping that extend from the extraction wells to the treatment building(s), existing infrastructure may limit the areas where extraction wells can be installed. The groundwater would be extracted at a rate sufficient to provide hydraulic control of each plume and reduce the highest contaminant

concentrations. Recovered groundwater would be treated and pumped to a surface water body that is approved by the state.

MNA would be used for the lower concentration distal portions of the plume outside of the GETS impact area. However, MNA would only be considered if available data indicate PRGs can be achieved in a time frame similar to that which would be required if an active remediation technology were employed.

Costs for Alternative 3 would be the highest of all the alternatives being evaluations. Significant capital costs would be required for the installation of the GETSs and extraction monitoring well network. Annual O&M and long-term monitoring (LTM) costs would be associated with the GETSs until PRGs are achieved or at least until it is determined that MNA would be a sufficient to address any remaining contamination. Costs associated with follow-on MNA would be similar to those in Alternative 2.

7.4 ALTERNATIVE 4: IN SITU CHEMICAL OXIDATION WITH MONITORED NATURAL ATTENUATION

Alternative 4 includes the aforementioned ICs with ISCO and MNA to address groundwater contamination.

For the ISCO portion of Alternative 4, an oxidant (and possibly other amendments such as iron catalysts, caustic, or acid) would be injected into injection wells that will be installed within the most highly contaminated portions of the plumes. Pilot studies would be required to determine the effects of different amendments that may be used (for example, to achieve metals mobilization). The fractured bedrock conditions at the Site would complicate amendment distribution and could result in pockets of contaminated groundwater remaining in the subsurface. Hydrofracturing or pneumatic fracturing could be employed to improve amendment distribution. Localized injection of the oxidant could achieve remediation of the most contaminated hotspots, significantly decreasing Site risks and the time for natural processes to achieve PRGs throughout the rest of the plume. Additional injection points would be necessary to adequately distribute the oxidant and amendments within the contaminated areas. It is expected that multiple rounds of injections would be necessary to complete treatment of the source areas. All site contaminants are potentially treatable with ISCO.

MNA would be used for the lower concentration distal portions of the plume and the areas not impacted by the ISCO. However, MNA would only be considered if available data indicate PRGs can be achieved in a time frame similar to that which would be required if an active remediation technology were employed.

Costs for ISCO should be less than those listed in Alternative 3 because the ISCO would reduce the time required to achieve PRGs. The major costs would be associated with the installation of injection and monitoring wells, purchase of oxidant and amendments, injection efforts, and performance monitoring. Costs associated with follow-on MNA would be similar to those in Alternative 2.

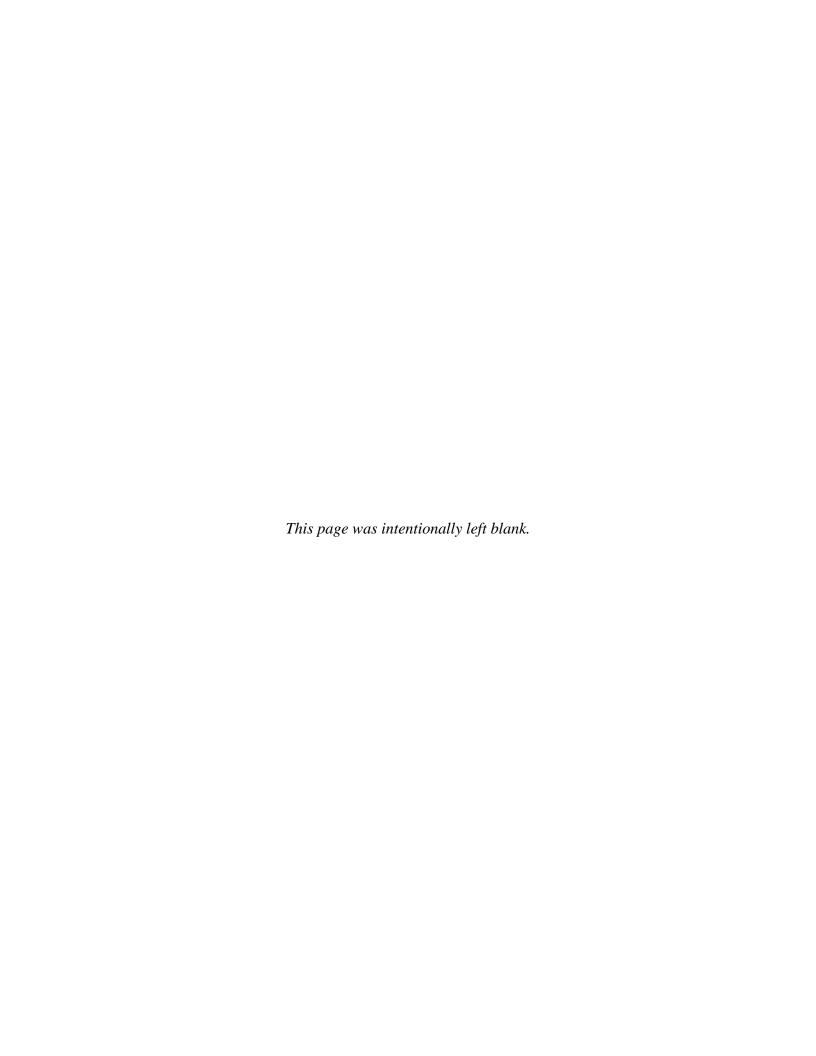
7.5 ALTERNATIVE 5: ENHANCED IN SITU BIOREMEDIATION WITH MONITORED NATURAL ATTENUATION

Alternative 5 includes the aforementioned ICs, with EISB and MNA to address groundwater contamination.

EISB of the groundwater contamination would be achieved by injecting nutrients and/or other amendments into injection wells that would be installed within the most contaminated portions of the plumes. Additional pilot studies may be required to determine if a different amendment (other than EOS) would be better suited to achieve treatment of the Site contamination and determine what doses would be required to reach the PRGs. Because of the lack of Dehalococcoides bacteria in the groundwater (determined during the Teleflex pilot study), inoculating groundwater with the bacteria could prove beneficial to achieve full degradation of TCE and its daughter products in a shorter time frame. A pH buffer would be used to prevent or limit degradation-related pH drop that might be harmful to the degrading microorganisms and reduce the effectiveness of the remedy. During the Teleflex pilot study the pH dropped from 7.06 to 4.56 in FS2 after the injection. The optimal pH range for anaerobic digestion with Dehalococcoides is between 6.8 and 7.5. The fractured bedrock conditions at the Site complicate amendment distribution and could result in pockets of contaminated groundwater remaining in the subsurface. Hydrofracturing or pneumatic fracturing could be employed to improve amendment distribution. Localized injection of the amendment(s) could achieve remediation of the most contaminated hotspots, significantly decreasing Site risks and the time for natural processes to achieve PRGs throughout the rest of the plume. Additional injection points would be necessary to adequately distribute the amendment within the contaminated areas. All Site contaminants are potentially treatable with EISB.

MNA would be used for the lower concentration distal portions of the plume and the areas not impacted by the bioremediation. However, MNA would only be considered if available data indicate PRGs can be achieved in a time frame similar to that which would be required if an active remediation technology were employed.

Costs for EISB would be less than those listed in Alternative 3 because the enhanced bioremediation would reduce the time required to achieve PRGs. EISB would be potentially less costly than Alternative 4, as there should be fewer injection events. The major costs would be associated with the installation of injection wells and monitoring, purchase of amendments and bacteria, injection efforts, and performance monitoring. Costs associated with follow-on MNA would be similar to those in Alternative 2.

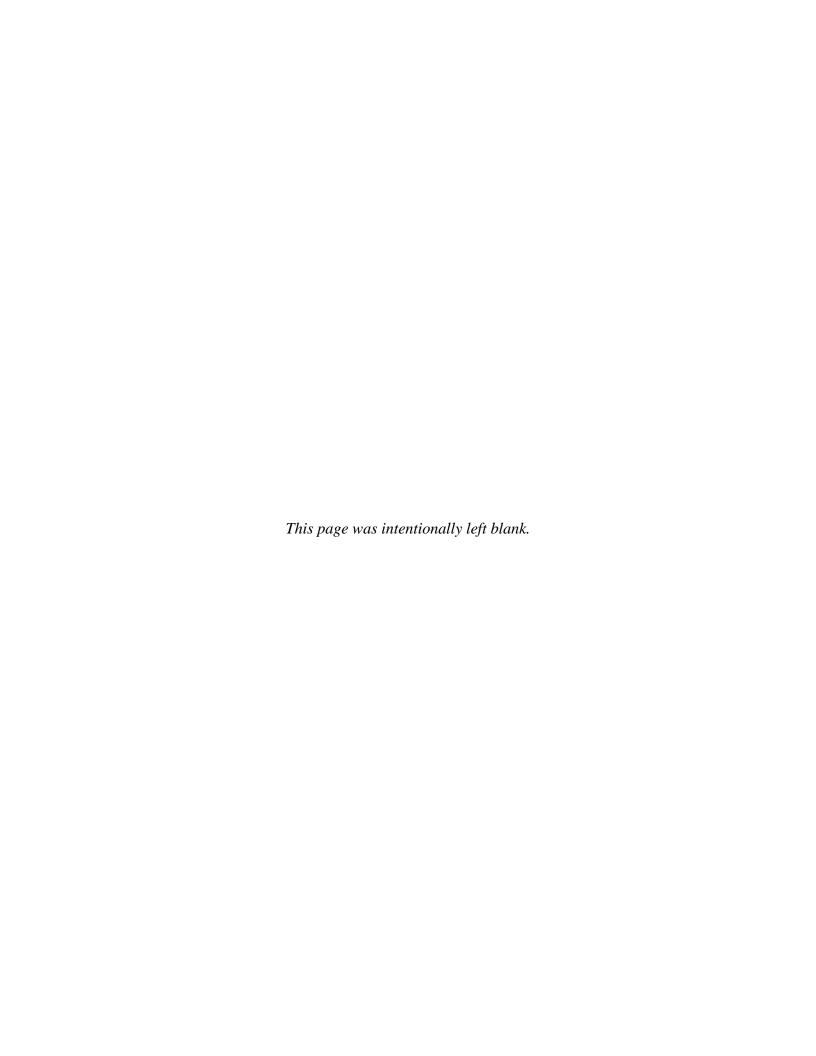


8.0 SCREENING OF REMEDIAL ALTERNATIVES

The alternatives presented in Section 7 were screened based on their effectiveness and implementability. The results of the screening are summarized in Table 8.1. The purpose of this screening evaluation is to reduce the number of alternatives that will undergo a more thorough and extensive analysis as the FS progresses. In terms of effectiveness, each alternative was ranked on a scale of 1 (complete destruction or removal of all Site contaminants) to 5 (no change in risks related to Site contamination). With regard to implementability, the alternatives were ranked on a scale of 1 (no construction or O&M required) to 5 (impossible to implement).

Based on the results of the screening evaluation, the following alternatives were carried forward for more detailed analysis:

- Alternative 1: No Action (required)
- Alternative 3: Groundwater Extraction Treatment with MNA and ICs
- Alternative 4: ISCO with MNA and ICs
- Alternative 5: EISB with MNA and ICs



9.0 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

This section presents a detailed analysis of the four potential remedial alternatives presented in Section 8.0 and retained as a result of the screening process. Each of the alternatives is evaluated against seven of the nine CERCLA evaluation criteria described in Section 9.1. A comparison of the potential remedial alternatives based on their relative performance against each of the evaluation criteria will be conducted in Section 10.0.

9.1 EVALUATION CRITERIA

The detailed analysis of alternatives was conducted in accordance with EPA's RI/FS Guidance (EPA, 1988a). The evaluation should provide decision-makers with sufficient information to adequately compare the alternatives, select an appropriate remedy, and demonstrate satisfaction of the CERCLA remedy selection requirements in the ROD. The first two criteria reflect statutory requirements of the ROD and are categorized as threshold criteria because any alternative must comply with them TBC a remedy. The next five balancing criteria are used to evaluate the retained alternatives by comparing the relative advantages and disadvantages of each remedial alternative. In most cases, a higher rating on one criterion can offset a lower rating on another balancing criterion. The seven evaluation criteria in conformance with the NCP for which the alternatives will be evaluated are as follows:

Threshold Criteria

- 1. Overall protection of human health and the environment, and
- 2. Compliance with ARARs.

Balancing Criteria

- 3. Long-term effectiveness and permanence,
- 4. Reduction of toxicity, mobility, and volume through treatment,
- 5. Short-term effectiveness,
- 6. Implementability, and
- 7. Cost.

The final two criteria are modifying criteria that are not evaluated in this FFS and will be addressed in the ROD based on comments received during the public comment period. These modifying criteria are as follows:

- 8. State acceptance, and
- 9. Community acceptance.

Each of the nine criteria, as it applies to the Site, is briefly discussed below.

9.1.1 Overall Protection of Human Health and the Environment

Each alternative is assessed to determine whether it can provide adequate protection of human health and the environment (short- and long-term) from unacceptable risks posed by hazardous

substances, pollutants, or contaminants present at the Site. Evaluation of this criterion focuses on how Site risks are eliminated, reduced, or controlled through treatment, engineered controls, or ICs and whether an alternative poses any unacceptable cross-media impacts.

9.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

For this criterion, each alternative is evaluated to determine how chemical-, location-, and action-specific ARARs presented in Section 3.0 are attained. To be selected for implementation, an alternative must meet all ARARs or have a justifiable basis to qualify for one of the six ARAR waivers allowed under CERCLA. In these cases, specific ARARs may be waived by authorized regulators to achieve threshold criteria, but the alternative must still be protective of human health and the environment.

9.1.3 Long-Term Effectiveness and Permanence

Long-term effectiveness evaluates the likelihood that the remedy will be successful and the permanence that it affords. Factors TBC, as appropriate, include the following:

- Magnitude of residual risk remaining from untreated waste or treatment residuals remaining at the conclusion of the remedial activities. The characteristics of the residuals are considered to the degree that they remain hazardous, taking into account their toxicity, mobility, or volume and propensity to bioaccumulate.
- Adequacy and reliability of controls used to manage treatment residuals and untreated waste remaining at the Site. This factor includes an assessment of containment systems and ICs to determine if they are sufficient to ensure that any exposure to human receptors is within protective levels. This factor also addresses the long-term reliability of management controls for providing continued protection from residuals, the assessment of the potential need to replace technical components of the alternative, and the potential exposure pathways and risks posed should the remedy need replacement.

9.1.4 Reduction of Toxicity, Mobility, and Volume

There is a statutory preference for remedies that permanently and significantly reduce toxicity, mobility, or volume of the hazardous substances. This criterion is used to evaluate the anticipated performance of the specific technologies an alternative may employ. The factors TBC include the extent to which total mass, volume, and/or mobility of contaminants are reduced; the toxicity of residuals resulting from the remedy; and to what extent the effects of treatment are irreversible.

9.1.5 Short-Term Effectiveness

This criterion is used to measure the effects of the various alternatives on human health and the environment during implementation of the remedial alternative, as well as the effectiveness of the proposed measures to protect the community, workers, and the environment.

9.1.6 Implementability

This FFS is not intended to serve as a design document, but to provide a more general conceptual overview of the alternatives and a general assessment of their relative feasibility. This criterion addresses the technical and administrative feasibility of implementing an alternative, including the availability of services and materials required for its implementation, the ease of construction and O&M considerations, the historical reliability of selected technologies, and the ease with which the alternative can be integrated with other RAs that might be necessary at the Site.

9.1.7 Cost

Cost estimates are developed according to A Guide to Developing and Documenting Cost Estimates During the Feasibility Study (EPA, 2000). The types of costs that are assessed for each alternative are as follows:

- Capital costs,
- Annual costs,
- Periodic costs, and
- Present value of capital and annual O&M costs.

The total cost for the RA includes capital and O&M costs, both direct and indirect. Capital costs consist of the direct costs for items such as labor, materials, equipment, and services plus the indirect costs for engineering management, permits, startup, and contingencies. Contingency ranging from 20 to 25 percent was utilized in the capital estimates for the alternatives (EPA, 2000). O&M costs are the annual costs necessary to maintain each alternative. O&M costs include such items as operating labor, maintenance, auxiliary materials, and energy.

The cost estimates provided in this FFS are all in projected 2018 dollars and are based on preliminary conceptual remedial alternative design anticipated from the technical data available at the time of preparation. Actual costs will depend on the final scope of work, the final design (plans and specifications) of the selected alternative, the implementation schedule, competitive market conditions, and other variables. Most of these factors are not anticipated to affect the relative cost differences between the alternatives presented in this FFS.

A present value analysis is used to evaluate expenditures that occur over different time periods by discounting all future costs to a common base year. The use of the present value cost analysis allows for the costs of remedial alternatives to be compared on the basis of a single figure. This comparative number represents the amount of money that, if invested in the base year and distributed as needed, will be sufficient to cover all costs associated with the life of the remedial project at an impacted site.

An assumption used for the present value cost estimates generated for this FFS includes a discount rate of 7 percent for the 30-year time frame, with 2018 as a base year (EPA, 2000). The cost estimates in this report are order-of-magnitude level estimates, which are based on a variety of information, including quotes from suppliers, Site investigation costs, vendor information, conventional cost estimating guides, and professional judgment. The cost estimates developed

during the analysis of alternatives should be considered preliminary and provide an expected range of approximately -30 to +50 percent accuracy (EPA, 2000).

9.1.8 State Acceptance

This assessment evaluates issues and concerns that the Commonwealth of Pennsylvania might have regarding each of the alternatives. State acceptance is not discussed in this analysis. It will be addressed in the ROD based on the state's comments on the FFS and the Proposed Plan.

9.1.9 Community Acceptance

Community acceptance is evaluated based on issues and concerns that the public might have regarding each of the alternatives. This criterion will also be addressed in the ROD after public comments on the Proposed Plan have been received.

9.2 DEFINITION AND INDIVIDUAL ANALYSIS OF ALTERNATIVES

In this section, all the alternatives retained for detailed analysis are further defined and evaluated based on the first seven evaluation criteria listed above. The following alternatives were retained for detailed analysis:

- Alternative 1: No Action (required)
- Alternative 3: Groundwater Extraction Treatment with MNA and ICs
- Alternative 4: ISCO with MNA and ICs
- Alternative 5: EISB with MNA and ICs

9.2.1 Alternative 1: No Action

9.2.1.1 Description

The No Action alternative is included as a baseline for comparison of other alternatives. No remedial activities or ICs would be implemented under this alternative, although some level of natural attenuation might occur. No further efforts, active remediation, or resources will be expended to remediate the contaminated groundwater in OU3. The performance of the No Action alternative with respect to each of the seven evaluation criteria is discussed below.

9.2.1.2 Overall Protection of Human Health and the Environment

Because no action would be performed, this alternative would not protect human health or the environment. Risks from groundwater contamination at the Site would not be significantly different from those identified in the RI. Therefore, this alternative will not be protective of human health and the environment.

9.2.1.3 Compliance with Applicable or Relevant and Appropriate Requirements

Because no action would be taken, the ARARs would not be met.

9.2.1.4 Long-Term Effectiveness and Permanence

This alternative includes no controls for exposure and no long-term management measures. All current and potential future risks would remain under this alternative.

9.2.1.5 Reduction of Toxicity, Mobility, and Volume

This alternative provides no significant reduction in toxicity, mobility, or volume of the contaminants in groundwater.

9.2.1.6 Short-Term Effectiveness

There would be no additional risks posed to the community, the workers, or the environment as a result of this alternative being implemented.

9.2.1.7 Implementability

There are no implementability concerns posed by this remedy because no action would be taken.

9.2.1.8 <u>Cost</u>

The only projected costs associated with Alternative 1 No Action are those associated with the FYRs that would be required for the Site.

9.2.2 Alternatives 3, 4, and 5: Common Elements

With the exception of the No Action alternative, all of the proposed remedial alternatives include some form of ICs in combination with other treatment or containment methods. The proposed ICs include Site use limitations that could be implemented through zoning ordinances, restrictive covenants, and access agreements. An air monitoring program, installation and maintenance of Site fencing, and warning signs to restrict unauthorized access to the Site would also be implemented during remediation activities.

The major common element between Alternatives 3, 4, and 5 is the inclusion of MNA for the plumes once COC concentrations in these areas are low enough that natural reductive dechlorination, dispersion, and dilution can potentially reach the PRGs in a time frame that is similar to what can be expected from use of active remediation technologies. Because each of these alternatives would need to show effectiveness of MNA before that portion of the remedy can be selected, each would require additional hydrogeologic investigation (determination of flow paths, contaminant migration rates, and contaminant degradation rates) to document the behavior and stability of the plume. Further, each alternative would require a ROD amendment for MNA once the required hydrogeologogic analyses are complete and indicate MNA can be successfully implemented. In addition, each of the alternatives includes the installation of 12 monitoring wells to assist in the performance evaluation. The sampling program in all three alternatives includes the same number of monitoring wells but the parameters analyzed and the sampling frequency differ between Alternatives 3, 4, and 5. Finally, a common element between Alternatives 4 and 5 is the need to drill injection points and conduct multiple injection events.

9.2.3 Alternative 3: Groundwater Extraction Treatment with MNA and ICs

9.2.3.1 Description

This alternative would remove and treat contamination from the highest concentration portions of the groundwater contamination plumes using two GETSs. Extraction of the contaminated groundwater will help provide hydraulic containment of contamination within the areas depicted in Figure 5.1. Using the GETSs to contain and withdraw the most contaminated groundwater will allow natural processes (e.g., dispersion, dilution, and degradation) to more effectively address lesser levels of contamination in the distal portions of the plumes. As a result, MNA would be considered as a remedy in those areas when low levels of site contaminants are achieved and evidence is sufficient to determine that the natural processes would achieve the PRGs as efficiently as more active remedial approaches. ICs to prevent the use of affected groundwater and allow access to properties for groundwater monitoring and necessary O&M activities are included as part of this alternative.

Alternative 3 includes two separate GETSs to treat the two contaminant plumes separated by the Wissahickon Creek. Initially the extracted water would go through a pair of duplexed 20-micron bag filters to remove suspended solids. It is assumed that all Site-related contaminants would be treated by air strippers with treatment of the off-gas by vapor-phase granular activated carbon. Each GETS would include a liquid-phase granular activated carbon unit to polish the effluent of the system to ensure discharge criteria are met. The treatment capacity of the GETSs would be designed to provide hydraulic control of each plume and reduce the highest contaminant concentrations.

The exact number, location, and depth of extraction wells would be determined during the RD phase. For estimating purposes, it is assumed that five extraction wells in the southern plume and three extraction wells would be installed in the northern plume. The depths of these eight extraction wells would vary from 100 ft bgs (five wells) to 500 ft bgs (one well). The two remaining extraction wells would be installed at depths of approximately 200 ft bgs. The installation of the eight extraction wells and conveyance piping would cost approximately \$750,000.

O&M costs for this alternative, including carbon replacements, filter replacement, disposal of spent media, and labor for treatment plant operators, treatment plant sampling, and reporting, would run approximately \$370,000 the first year. The cost for system startup, commissioning, and optimization is included. Sampling of the influent groundwater, treated effluent, untreated air-stripper off-gas, and treated discharge air would be conducted monthly in the first year and quarterly for the remaining years of operation.

To monitor the performance of both GETSs, an additional 12 monitoring wells will be installed. A baseline sampling event would be conducted once the GETSs are configured. The long-term groundwater monitoring program would include approximately 60 wells, including the eight extraction wells. These would be sampled quarterly the first year, semiannually for the next three years, and with a possible switch to annual sampling of a reduced number of wells thereafter. Groundwater elevations would be tracked routinely throughout the groundwater extraction period to monitor the hydraulic capture effectiveness of the GETSs and help determine which areas would be most amenable to MNA. The LTM costs, including associated reporting, and project

management, would vary from \$30,000/year (annual frequency) to \$155,000/year (quarterly frequency). Also, FYRs and ICs inspections would be required until the cleanup goals for the Site are achieved. These additional activities would add \$41,000 every 5 years.

9.2.3.2 Overall Protection of Human Health and the Environment

Alternative 3 protects human health and the environment through implementation of ICs, which would prevent unacceptable exposures to contaminated groundwater. The construction of the two GETSs would prevent spread of contamination via the groundwater pathway. It is possible that the GETSs would treat groundwater to the point that restrictions on groundwater use could be removed. In distal portions of the plume, decreases in contaminant concentrations achieved through natural processes also could allow the eventual removal of the restriction on groundwater usage.

9.2.3.3 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 3 should require more than 30 years to achieve the cleanup goals. All the components of the groundwater extraction system comply with federal and state ARARs. Treatment of groundwater using this system would meet the substantive requirements of the State Water Pollution Control Act, Clean Water Act (CWA), Pennsylvania Air Pollution Control Code (Air Code), and Clean Air Act (CAA). Any installation, modification, or abandonment of monitoring wells or extraction wells would be performed in accordance with Pennsylvania's Water Well Driller License Act. Solid waste and waste residuals (such as spent GAC) generated by the vapor collection and treatment system would be profiled and disposed of in compliance with the associated Resource Conservation and Recovery Act (RCRA) regulations, Residual Waste Handling provisions, and the Pennsylvania Hazardous Waste Management Regulations (PHWMR), including any land disposal restrictions. Discharge of treated water would comply with the substantive requirements of the Pennsylvania Clean Streams Law. An Erosion and Sediment Control Plan would be developed and implemented to protect the surrounding areas from runoff during drilling and construction activities. Air emissions generated by air stripper system would need to comply with CAA and the Pennsylvania Air Code. The types and frequency of air monitoring activities necessary to meet these requirements will be finalized during the RD activities.

9.2.3.4 Long-Term Effectiveness and Permanence

Groundwater treatment is expected to achieve high long-term effectiveness and permanence assuming it is properly designed, constructed, operated, and maintained. The proposed components of the GETS have been utilized at sites with the same COCs at similar concentrations. The GETS, as currently envisioned, would be effective in reducing the contaminant mass and controlling plume migration. One potential problem could be a lack of sufficient contaminant reduction within a reasonable time frame. ICs would remain in place to ensure that any residual risks associated with site groundwater remain low. Once the GETSs establish containment of the highest concentration portions of the plume, it is expected that MNA will be effective in achieving cleanup goals in the more distal portions of the plume. GETS operation would require routine and nonroutine maintenance for more than 30 years.

9.2.3.5 Reduction of Toxicity, Mobility, and Volume

The GETS would control the mobility of the contaminants by extracting contaminated groundwater from both plumes. The contaminated water would be treated by filtration, volatilization of organic contaminants, and carbon adsorption, thereby reducing the toxicity and volume of the Site contaminants in groundwater. MNA processes will reduce the volume and toxicity of lower concentration portions of the contaminant plumes once the GETSs have achieved hydraulic control of the source areas.

9.2.3.6 Short-Term Effectiveness

The estimated time to achieve cleanup goals for groundwater with Alternative 3 is more than 30 years. Therefore, it has no significant short-term effectiveness for the contaminated groundwater plume. Proper controls during installation of extraction wells would minimize the risks to workers and the community. Erosion and sediment controls would be used to mitigate runoff. Remedial workers would require protection against dermal contact and inhalation of vapors during construction of extraction wells, treatment systems, and operation of the GETSs as specified in a health and safety plan. Site workers would be protected from these potential exposures through the use of proper personal protective equipment (PPE) and proper workplace safety procedures. It is not anticipated that there would be a detrimental effect to the community from increased noise or increased road traffic during the drilling and construction activities. Minimal effort would be required to establish and enforce exclusion zones during Site work. Exposure to VOCs from emissions would be mitigated by the vapor phase GAC system. ICs would protect human health in the short term by prohibiting the use of area groundwater for potable use.

9.2.3.7 <u>Implementability</u>

All the materials and services needed for both GETSs are standard and are readily available from vendors. Treatment effectiveness can be monitored by collecting water samples from the influent and effluent lines. Cleanup effectiveness would be monitored through the continued sampling of Site monitoring wells. One challenging component of this alternative is the need to acquire/lease land to construct the two buildings and conveyance piping. Administrative challenges associated with construction of the buildings and timing and interfacing of different technologies would be managed through detailed planning and discussion with the regulators. The systems would be flexible to incorporate alternative technologies, improvements, or changes in capacity.

The approximate time to implement this alternative is one year after the RD has been completed and all the necessary permits and property have been obtained. During the design phase, a comprehensive report will document the findings of site investigations (e.g., aquifer testing) that will be required to assist in determining the number and placement of wells and the capacity and exact technologies of the treatment train. The Pennsylvania Department of Environmental Protection (PADEP) National Pollutant Discharge Elimination System discharge permit equivalencies would be required for surface water discharge. PADEP air permit equivalencies also would be required for the GETSs off-gas discharges. Any modification or abandonment of monitoring wells or injection wells would be performed in accordance with Pennsylvania's Water Well Driller License Act. Long-term administrative resources would be required to ensure enforcement of the ICs, maintenance of the GETSs, and completing FYRs.

9.2.3.8 <u>Cost</u>

This section presents the present worth analysis for Alternative 3. Uncertainties that could impact the total cost of this alternative include: the number and locations of the extraction wells and the need to address the metals contamination with a more advanced filter media. It is estimated that Alternative 3 would require the following:

- A capital expenditure of \$4.78M, which includes the costs of designing the two GETSs; installing the extraction wells and conveyance piping; constructing the treatment system buildings; purchasing tanks, air stripper systems, vapor and liquid GAC units, bag filter units; installing control systems; conducting project and construction management, and installing/extending utilities.
- A combined cost of \$750,000 for O&M of the two GETSs for the first year of operation and \$250,000 per year thereafter;
- An additional cost of \$210,000 to \$750,000 for monitoring well installation.

Additional costs of approximately \$40,000 (incurred every 5 years) would be incurred for monitoring ICs and conducting each FYR that would be required until PRGs are met for all Site-related contaminants. Finally, approximately \$150,000 for the first year and then \$75,000/year for the next three years thereafter for LTM, associated reporting, and project management are included. These costs would be \$20,000/year for the remaining years of GETS operation. Table 9.1 presents the cost summary associated with Alternative 3. The total estimated present worth cost (2018 dollars) is \$10,640,511. Detailed and backup data regarding the cost estimate are presented in Appendix B.

9.2.4 Alternative 4: In Situ Chemical Oxidation with MNA and ICs

9.2.4.1 Description

Alternative 4 initially consists of using ISCO to remediate the COCs in the source area. As the source area contaminants are oxidized, natural processes (e.g., dispersion, dilution, and degradation) would more effectively address lesser levels of contamination in the distal portions of the plumes. As a result, MNA would be considered as a remedy in those areas when low levels of Site contaminants are achieved and evidence is sufficient to determine that the natural processes would achieve the PRGs as efficiently as more active remedial approaches. ICs to prevent the use of affected groundwater and allow access to properties for groundwater monitoring and follow-on injections are included as part of this alternative.

A number of oxidants are commercially available. Potassium permanganate and sodium permanganate are very effective in destroying chlorinated ethenes. Catalyzed sodium persulfate is an aggressive oxidant that can degrade all of the organic COCs. Persulfate, however, is more expensive than permanganate. For costing purposes, the use of permanganate is assumed; however, a pilot study should be conducted to select the most suitable oxidant. Potassium permanganate has a low aqueous solubility and thus requires a larger injectate volume than sodium permanganate. For this reason, it was assumed that sodium permanganate would be used for Alternative 4.

The oxidant demand value assumed for costing purposes includes the contaminant oxidant demand and natural oxidant demand. To account for permanganate reaction with natural materials such as ferrous iron, sulfides, and natural organic carbon and to effectively treat chlorinated VOCs at the Site (based on average TCE concentrations), it is assumed that seven grams of sodium permanganate per kilogram of soil are needed. The pilot study would determine the exact application rate for sodium permanganate. In total, it is estimated that 400,000 pounds of sodium permanganate would be injected throughout the areas depicted in Figure 9.1.

Sodium permanganate is shipped as a 40 percent by weight solution. It was assumed that the oxidant would be diluted to a 10 percent by weight solution before injection. The estimated number of injection points that would be needed was calculated using an ROI of 30 ft, based on the observed injection distribution results from the in-situ bioremediation pilot study. Assuming a 20 percent overlap, the total number of injection points that would be needed for each injection area (as shown on Figure 9.1) are:

- 1. Teleflex Area (440,000 ft²): 189 points
- 2. Ford Facility (150,000 ft²): 64 points
- 3. Spra-Fin (278,000 ft²): 119 points
- 4. Spra-Fin 2 (32,000 ft²): 14 points

A higher rate of injection may increase the ROI of injection points, which in turn would produce cost savings. However, variability in fracture size, orientation, and connectivity may limit achievable ROI in some portions of the treatment area. Costing in this FFS has been based on the limited pilot test injection data. Further pilot testing could support higher injection rates to achieve larger ROI. Additional ROI testing should be considered as part of the RD for the Site.

Sodium permanganate is soluble and should be readily distributed away from the injection point. Hydrofracturing or pneumatic fracturing could be employed to improve amendment distribution, but costs related to that option have not been included in this document. It is estimated that the initial oxidant injection would take approximately 22 weeks to complete. It is expected that the design, including a pilot study, and the first round of oxidant injections would be completed during the first two years.

ISCO is prone to contaminant rebound. Across a given injection interval, amendments preferentially flow through the more transmissive zones. Once the oxidant has been consumed, contaminants from other fractured zones can diffuse into the more transmissive zones and cause contaminant rebound. For costing purposes, it was assumed that two additional rounds of oxidant injections would be performed, and that additional injections would start two years after completion of the prior injection. It was assumed that the second oxidant injection would encompass 50 percent of the initial treatment area, and the third injection would encompass 25 percent of the initial treatment area. Depending on the extent of contaminant rebound, additional rounds of oxidant injection could be required.

Similar to Alternative 3, LTM is included in this alternative. A baseline sampling event would take place prior to oxidant injections. The LTM would occur quarterly for the first year following oxidant injection, semiannually for the next nine years, and annually for an additional five years.

Samples would be collected from 60 wells, including the 12 new monitoring wells that will be installed to monitor the performance of the injections. Samples would be analyzed for MNA parameters in addition to VOCs. Groundwater elevations would be tracked routinely throughout the remedy performance period to help determine areas that might be amenable to MNA. Samples would also be analyzed for metals to monitor solubility/mobility changes that might occur as a result of the ISCO. It is expected that the monitoring program would be optimized once enough data have been collected to establish remedy performance and concentration trends. To ensure protection of human health while remediation is ongoing, Alternative 4 would include ICs. Inspections would be performed semiannually with the results documented in an annual report. FYRs would be completed to assess the remedy's protectiveness.

9.2.4.2 Overall Protection of Human Health and the Environment

Alternative 4 protects human health and the environment through implementation of ICs, which would prevent unacceptable exposures to contaminated groundwater. In addition, Alternative 4 would treat VOCs in both plumes and restore the groundwater to cleanup standards. All ICs would remain in place until PRGs are achieved. It is anticipated that after the third round of oxidant injections, the remaining areas with low-level contamination could be addressed through MNA. The removal of ICs would be dependent on how quickly the remaining contamination attenuate to meet the PRGs.

9.2.4.3 Compliance with Applicable or Relevant and Appropriate Requirements

Based on a detailed evaluation of Alternative 4, it complies with all relevant potential ARARs as described for Alternative 3. It is anticipated that Alternative 4 could take up to six years if three injections events are required and nine years of subsequent MNA to achieve the chemical-specific ARARs. Wastes generated during oxidant injection and groundwater monitoring activities would include decontamination water, disposable sampling equipment, and PPE. All waste streams would be managed and disposed of in accordance with federal and state regulations as described in Alternative 3. The oxidant injections would comply with the substantive requirements of the UIC Regulations as stated in the Safe Drinking Water Act and any corresponding state programs.

9.2.4.4 Long-Term Effectiveness and Permanence

ISCO is a proven technology for contaminant destruction. Sodium permanganate can effectively degrade the chlorinated ethenes with which it comes into contact. The primary risks with ISCO are uniform oxidant distribution in the treatment zone and contaminant rebound. Alternative injection techniques, such as pneumatic fracturing, could be used to enhance oxidant distribution if determined to be necessary. Contaminant rebound could be addressed through repeated oxidant applications. Alternatively, slow release oxidant "candles" could be used to provide a long-term supply of oxidant to degrade COCs that diffuse out of lower permeability zones or desorb in hairline fractures.

9.2.4.5 Reduction of Toxicity, Mobility, and Volume

Alternative 4 would decrease contaminant mass, and thereby toxicity and mobility, in all four areas depicted in Figure 9.1 through the injection component. With time, the decreased contaminant flux

from these four areas combined with natural attenuation of the distal portions of the plumes would decrease the volume of contaminated material in the aquifer.

9.2.4.6 Short-Term Effectiveness

Even though the Site is located in an industrial or light industrial area, there are nearby residential communities that could be affected by on-site operations. Once the injections points are drilled, the only major concerns would be the increased traffic and the noise during the oxidant injections. However, it is anticipated that only those workers associated with implementation of the alternative would be at or near the treatment areas during these times. Oxidants are reactive and must be handled with care. With this alternative, it would be necessary to assess the oxidant's compatibility with any subsurface structures and, if not compatible, adjust the injection technique to avoid exposing the structure(s) to the oxidant solution. Care would be necessary to ensure that the oxidant is not spilled and that the oxidant solution does not daylight during injection. Safe storage and handling of the oxidant both in its shipped and diluted forms are imperative. Standard safety precautions would be used to prevent injuries during drilling and oxidant application. A large quantity of oxidant would need to be transported to the Site and could cause public or environmental harm if spilled. The transport of materials and equipment to the Site also carries the risk of traffic accidents. These risks can be minimized by using only appropriately trained and licensed drivers and ensuring that all transportation activities are performed in accordance with all federal and state transportation regulations.

Alternative 4 would pose minimal short-term effects on the environment because most of the injections would occur in paved areas. Placing absorbent socks and mats around the injection locations would further minimize the potential risks associated with the ISCO activities. The ground surface (parking lots and asphalt roads) would be disturbed by drilling activities. The contractor who implements this alternative would need to work with the existing businesses to ensure no disturbance to their operations.

9.2.4.7 Implementability

ISCO is an established technology that is widely used for remediation projects. Injection contractors, equipment, and materials are readily available in the vicinity of the Site. ISCO would require an UIC permit equivalence that should be relatively easy to obtain. The initial oxidant injection is estimated to take 22 weeks to complete. More than one round of oxidant injection would be required. In general, the Site is accessible to drilling equipment. Vegetation clearing may be necessary in some locations. While feasible, this alternative, because of the injection activities within ongoing industrial activities, will require significant administrative coordination with existing businesses and the surrounding community.

9.2.4.8 Cost

The costs associated with this alternative include ISCO bench-scale study, three rounds of sodium permanganate injection, professional services, monitoring well installation, post-injection and LTM, completion of summary reports for the RA and post-injection sampling events, land use control inspections and FYRs. The cost for the initial round of sodium permanganate injection, including the drilling of the injection points and oversight is approximately \$7.4M. This cost would

be reduced for additional injection events due to fewer injection points (so less oxidant needed) and the fact that the drilling costs are included in the first injection round. Table 9.2 tabulates all these capital costs and LTM and periodic costs. The latter costs are higher than the costs in Alternative 3 because samples would also be analyzed for MNA parameters. The total estimated present worth cost (2018 dollars) associated with Alternative 4 is \$9,786,359. Backup data regarding the cost estimate is presented in Appendix B.

9.2.5 Alternative 5: Enhanced In Situ Bioremediation with MNA and ICs

9.2.5.1 Description

Alternative 5 initially consists of applying EISB in the four injection areas depicted in Figure 9.1 As the source area contaminants are degraded, natural processes (e.g., dispersion, dilution, and degradation) would more effectively address lesser levels of contamination in the distal portions of the plumes. As a result, MNA would be considered as a remedy in those areas when low levels of Site contaminants are achieved and evidence is sufficient to determine that the natural processes would achieve the PRGs as efficiently as more active remedial approaches. ICs to prevent the use of affected groundwater and allow access to properties for groundwater monitoring and follow-on injections are included as part of this alternative.

Based on the pilot study, EISB would be achieved by injecting EOS, nutrients, and bacteria if necessary in the source areas to achieve full degradation of TCE and its daughter products in a shorter time frame. Iron and manganese concentrations in groundwater are expected to increase as a result of the reducing conditions imparted by the substrate injections, but they would return to background levels after EISB treatment ceases.

For costing purposes, it is assumed that every injection point would receive 880 pounds of EOS PRO. The same number of injections points that was estimated in Alternative 4 has been assumed in this alternative. The fractured bedrock conditions at the Site complicate amendment distribution and could result in pockets of contaminated groundwater remaining in the subsurface. For costing purposes, installation of injection wells at each injection point was assumed, although other injection techniques, such as hydrofracturing or pneumatic fracturing could be employed to improve amendment distribution. It is also assumed that a second injection event, that would encompass 50 percent of the initial injections points, would be needed to address contaminant rebound. The first injection round would take approximately 22 weeks, while the second round would occur over 6 weeks. Depending on the extent of contaminant rebound, additional rounds of EOS PRO injection or more injection points could be required in the second round.

A higher rate of injection may increase the ROI of injection points, which in turn would produce cost savings. However, variability in fracture size, orientation, and connectivity may limit achievable ROI in some portions of the treatment area. Costing in this FFS has been based on the limited pilot test injection data. Further pilot testing could support higher injection rates to achieve larger ROI. Additional ROI testing should be considered as part of the RD for the Site.

Similar to Alternatives 3 and 4, LTM is included in Alternative 5. A baseline sampling event would take place prior to EISB injections. LTM would occur quarterly for the first year following oxidant injection, semiannually for the next 3 years, and annually for the remainder of the costing period.

Samples would be collected from 60 wells, including the 12 new monitoring wells that will be installed to monitor the performance of the injections. The exact location of the monitoring locations will be determined during the RD phase. Samples would be analyzed for MNA parameters in addition to VOCs and metals. It is expected that the monitoring program would be optimized once enough data have been collected to establish remedy performance and concentration trends. Groundwater elevations would be tracked routinely throughout the remedy performance period to help determine areas that might be amenable to MNA. Monitoring well locations and the specifics of the long-term monitoring program will be determined during the RD. To ensure protection of human health while remediation is ongoing, Alternative 5 would include ICs. Inspections would be performed semiannually with the results documented in an annual report. FYRs would be completed to assess the remedy's protectiveness.

9.2.5.2 Overall Protection of Human Health and the Environment

This alternative would adequately protect human health and the environment degrading the organic contamination though EISB in source areas and MNA implementation in the distal areas of the plumes. As long as they are maintained, ICs are an effective approach for controlling or eliminating potential human exposure to site contaminants.

9.2.5.3 Compliance with Applicable or Relevant and Appropriate Requirements

Under Alternative 5, the chemical-specific ARARs for groundwater would be achieved in 10 years, only four years after the second round of injections. The substantive provisions of all ARARs, such as the provisions of Pennsylvania Clean Streams Law, CWA, Safe Drinking Water Act (UIC regulations), Water Well Driller License Act, and Storm Water Management Act would be met to avoid adverse effects during injection events and other field activities. All waste streams would be managed and disposed of in accordance with federal and state regulations as described in Alternative 3.

9.2.5.4 Long-Term Effectiveness and Permanence

It is anticipated that PRGs for the groundwater contaminants in both plumes would be achieved within ten years, including post injection monitoring. However, iron and manganese (particularly manganese) could exceed cleanup standards for several additional years until the aquifer pH, oxidation reduction potential, and other geochemical attributes in the EISB areas return to preinjection levels. Injection techniques, such as pneumatic fracturing, can promote amendment distribution, but were not assumed for costing purposes in this document. Targeting specific hot spot areas with multiple rounds of injections would achieve a high rate of contaminant removal. The residual risks regarding the groundwater would be low as groundwater use as a potable source is currently prohibited in the vicinity of the Site. Sampling data appear to indicate that natural attenuation is already occurring; indicating that the distal areas of the plumes, which are not part of the four targeted injection areas, would eventually meet the PRGs. ICs would remain in place until they are no longer needed.

9.2.5.5 Reduction of Toxicity, Mobility, and Volume

The reduction in toxicity, mobility, and volume through treatment is the same as described for Alternative 4, with the exception that chlorinated VOCs are expected to meet PRGs in a shorter timeframe under Alternative 5.

9.2.5.6 Short-Term Effectiveness

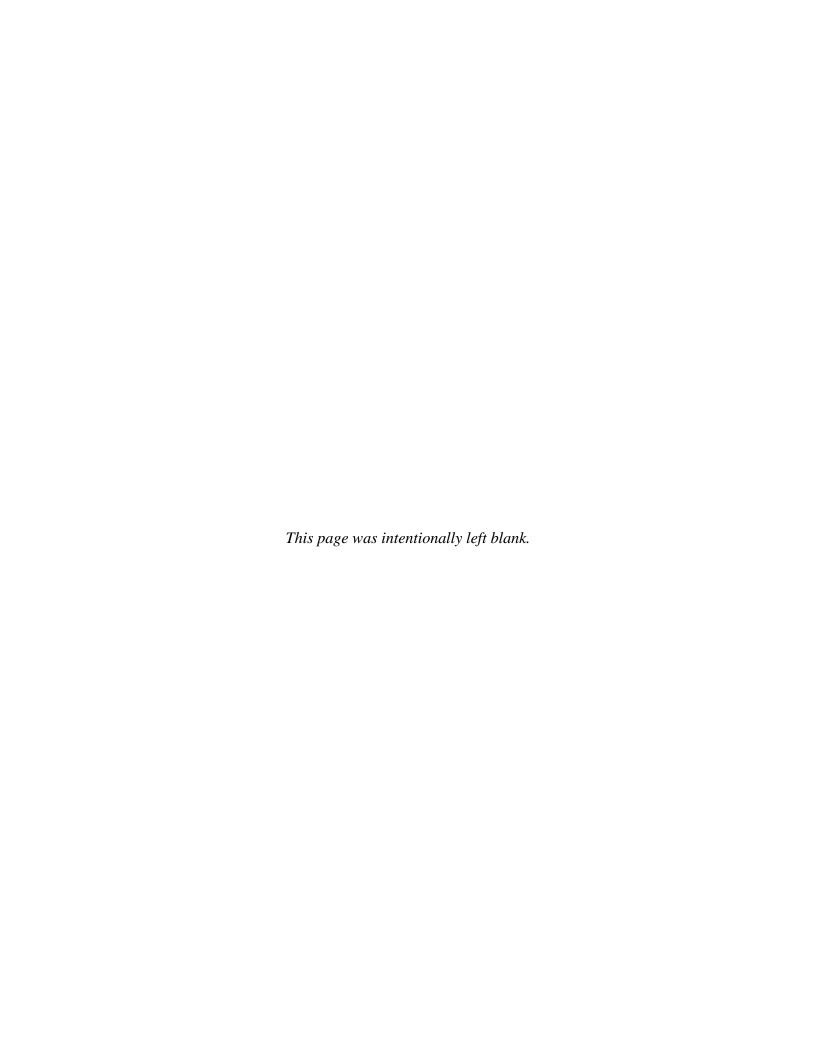
The short-term effects are the same as described for Alternative 4 except that the risks associated with the oxidants would be eliminated.

9.2.5.7 <u>Implementability</u>

EISB is an established technology that is widely used for remediation projects. Injection contractors, equipment, and materials are readily available in the vicinity of the Site. EISB would require an UIC permit equivalence that should be relatively easy to obtain. The initial injections are estimated to take 22 weeks to complete. More than one round of injections would be required. In general, the Site is accessible to drilling equipment. Vegetation clearing may be necessary in some locations. While feasible, this alternative, because of the injection activities within ongoing industrial activities, will require significant administrative coordination with existing businesses and surrounding community.

9.2.5.8 <u>Cost</u>

Table 9.3 presents the cost summary associated with Alternative 5. The total estimated present worth cost (2018 dollars) is \$7,467,690. The costs cover drilling a total of 386 injection points in four areas, two EISB injection rounds, installation of groundwater monitoring wells, post-injection/long term monitoring sampling, completion of summary reports for the RA and sampling events; implementation of ICs; and submittal of two FYRs. The cost for the initial round of EISB injection, including drilling the injection points and oversight is approximately \$6.3M. These costs would be substantially less for the second injection round due to fewer injection points (so a smaller volume of amendments would be needed) and the fact that the drilling costs are included in the first injection round. The monitoring costs are comparable with the costs in Alternative 4. Backup data regarding the cost estimate is presented in Appendix B.



10.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

In this section, the remedial alternatives developed for the groundwater remedy at OU3 are compared to each other to determine how well they satisfy the first seven evaluation criteria presented in Section 9.1. Alternative 1, No Action, does not meet the first two criteria of protectiveness and compliance with ARARs. Therefore, no further evaluation or scoring is included in the following sections for this alternative.

10.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

The appropriate implementation of ICs under Alternatives 3, 4, and 5 would cut off exposure pathways and thereby eliminate potential risks to human health. Alternatives 3, 4, and 5 would all reduce human health risks from groundwater in the source areas to the levels specified in Section 4 of this FFS Report by either extracting and treating contaminated groundwater or injecting specific amendments. ICs, implemented as part of all three alternatives, would ensure protection of human health until PRGs are achieved. Following containment or treatment of the source area contamination, MNA would be effective in reducing human health risks in the distal plume areas.

10.2 COMPLIANCE WITH ARARS

Assuming that Alternatives 3, 4, and 5 are implemented properly, each should achieve compliance with all identified ARARs in a reasonable timeframe. It is likely that Alternative 3 would take longer to achieve compliance with PRGs than either of the two in situ treatment alternatives. The provisions of the CWA and the regulations of the National Emissions Standards for Hazardous Air Pollutants are the most significant for Alternative 3. For all three alternatives, the RCRA and PHWMR sections are applicable for categorization, handling and disposal of any solid or liquid waste. Alternatives 4 and 5 must also comply with the provisions of the UIC Regulations.

10.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

Alternatives 3, 4, and 5 have the potential to be equally effective over the long term because the most contaminated areas would be remediated with groundwater extraction or amendment injections. The treatment of the contaminated groundwater through the two GETSs in Alternative 3 would require the longest time to achieve cleanup goals. Multiple rounds of oxidant or EOS injections would be required to achieve the PRGs in Alternatives 4 and 5 but in a considerable shorter timeframe than Alternative 3.

The least amount of uncertainty with respect to treatment effectiveness and efficiency is associated with Alternative 5 because of the effectiveness observed in the pilot study, while Alternative 4 contains the greatest amount of uncertainty since no pilot study data are available to evaluate the effectiveness of ISCO. Alternative 3 can be designed and implemented to address all contamination and has a great degree of flexibility to overcome unforeseen hydraulic capture issues or treatment requirements.

10.4 REDUCTION OF TOXICITY, MOBILITY OR VOLUME

Alternatives 3, 4, and 5 would reduce the toxicity, mobility, and volume of the VOCs through treatment. Alternative 5, which would introduce a temporary reducing environment during treatment of the source areas, would increase soluble metals concentrations in the short run. It is therefore ranked lower than Alternative 4, in which the oxidizing environment would decrease metals solubility temporarily. Alternative 3 is expected to reduce inorganics levels over the long term as source area groundwater containing Site-related metals contamination is withdrawn.

Alternative 5 will include the installation of additional monitoring wells and surface water monitoring locations to the long-term monitoring plan. The exact location of the monitoring locations will be determined during the RD phase.

10.5 SHORT-TERM EFFECTIVENESS

Short-term risks to construction workers, surrounding communities, and the environment are expected to occur from the implementation of Alternatives 3, 4, and 5. Alternatives 3, 4, and 5 pose short-term impacts to the surrounding community due to increased vehicle traffic and noise from treatment, as well as an increased personnel presence in the area. Short term risks associated with Alternatives 3, 4, and 5 can be managed by a combination of Site controls, PPE, vapor and dust suppression and collection measures, and safe work procedures. Alternatives 3, 4, and 5 would all require coordination with the local government and existing businesses. Local impacts from the injections in Alternatives 4 and 5 are expected to be shorter term and easier to coordinate than the one to two year construction and testing of the two GETSs and ongoing O&M. For Alternative 3, remedial workers would potentially be exposed to site-related contamination through dermal contact and inhalation of vapors during construction of extraction wells, remedy monitoring, and O&M of the treatment systems. Potential worker exposure for Alternatives 4 and 5 would be limited to injection well installations, injection activities, remedy monitoring, and, in the case of Alternative 4, pilot testing. Alternative 3 would take more than 30 years, Alternative 4 would take approximately 15 years, and Alternative 5 would take less than 10 years.

10.6 IMPLEMENTABILITY

All alternatives are technically and administratively feasible. Contractors, equipment, materials, and technical services are readily available for each alternative. Alternatives 3 would require aquifer testing to optimize extraction well placement, and startup testing to ensure that the selected treatment train achieves the required discharge standards. Alternative 4 would require a pilot study to determine the actual ROI, oxidant, delivery rate, delivery pressure for the injections, and appropriate injection technology. Alternative 3 has a higher degree of constructability with the inclusion of two GETSs and eight extraction wells, along with associated trenching and conveyance piping. The level of construction and infrastructure in Alternatives 4 and 5 is similar. It is anticipated that the potential risks for damaging existing infrastructure are greater with Alternative 3 than implementing Alternatives 4 or 5 because of the need to run conveyance piping, but this can be addressed through proper prelocation of existing utilities. Because of the number of injection points required for Alternatives 4 and 5, it is expected that more access agreements will be required for these options than for Alternative 3. However, Alternative 3 will require

purchase of property or easements for the treatment buildings, extraction wells, conveyance piping, and utilities.

10.7 COST

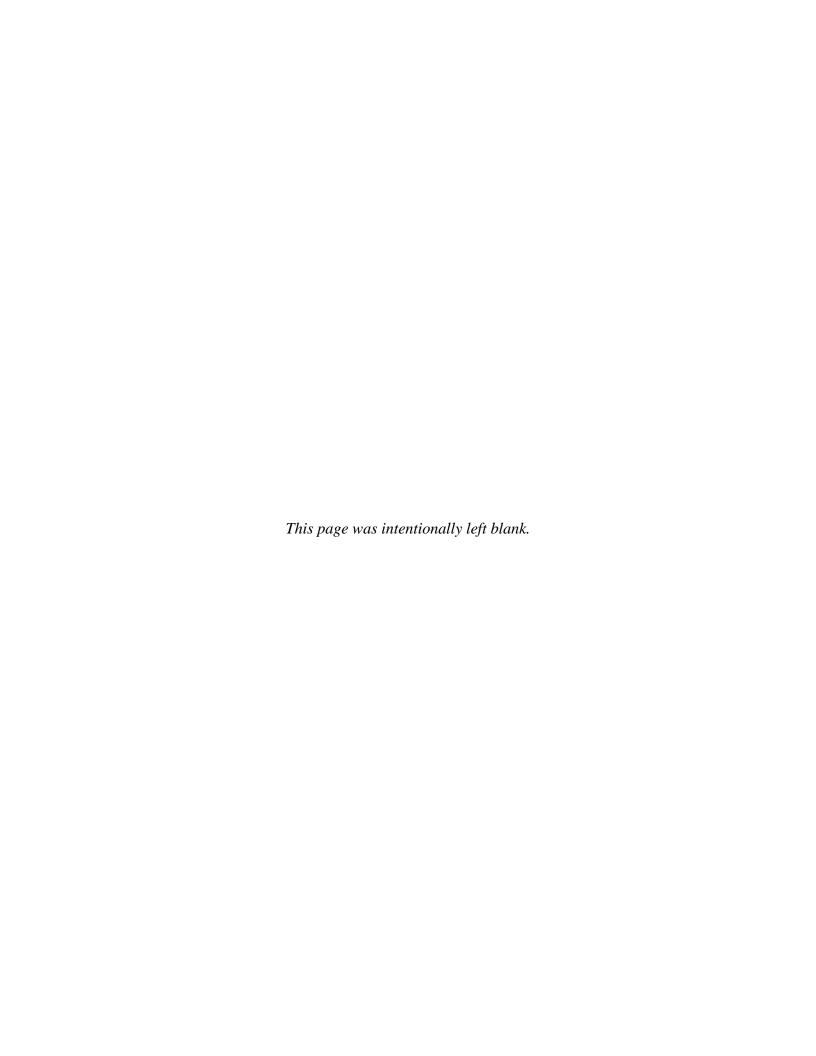
As anticipated, the cost of the bioremediation injections in Alternative 5 is less than the cost of Alternative 3 with two GETSs. Cost estimates for Alternative 4 will change once pilot studies better define the necessary parameters for the oxidant demand and ROI, but it is expected that the costs associated with Alternative 4 would be higher than the cost for Alternative 5. The costs for Alternative 5 are the least subject to change based on the relative lack of uncertainty with respect to the amount of amendment that would be required to achieve degradation of the source area contaminants. Alternatives 4 and 5 likely would be less expensive than Alternative 3 even in the scenario where additional injection events, other than those already accounted for, are needed.

The 30-year present value costs, assuming a discount rate of 7 percent stipulated by the EPA guidance (EPA, 2000), and the total costs escalated for inflation (assuming a yearly inflation rate of 1.5 percent) for all three alternatives are presented in tabular form below. The cost estimates included in this report are budgetary with an uncertainty of -30 percent to +50 percent.

	Alternative 3	Alternative 4	Alternative 5
Total Cost without Inflation	\$16,062,988	\$11,396,911	\$8,407,465
Total Cost with Inflation	\$18,446,014	\$11,717,063	\$8,539,690
30-Year Present Value Cost	\$10,640,511	\$9,786,359	\$7,467,690

10.8 STATE AND COMMUNITY ACCEPTANCE

As stated earlier, the state and community acceptance criteria will be addressed during and following the issuance of the proposed plan and the subsequent public comment period.



11.0 REFERENCES

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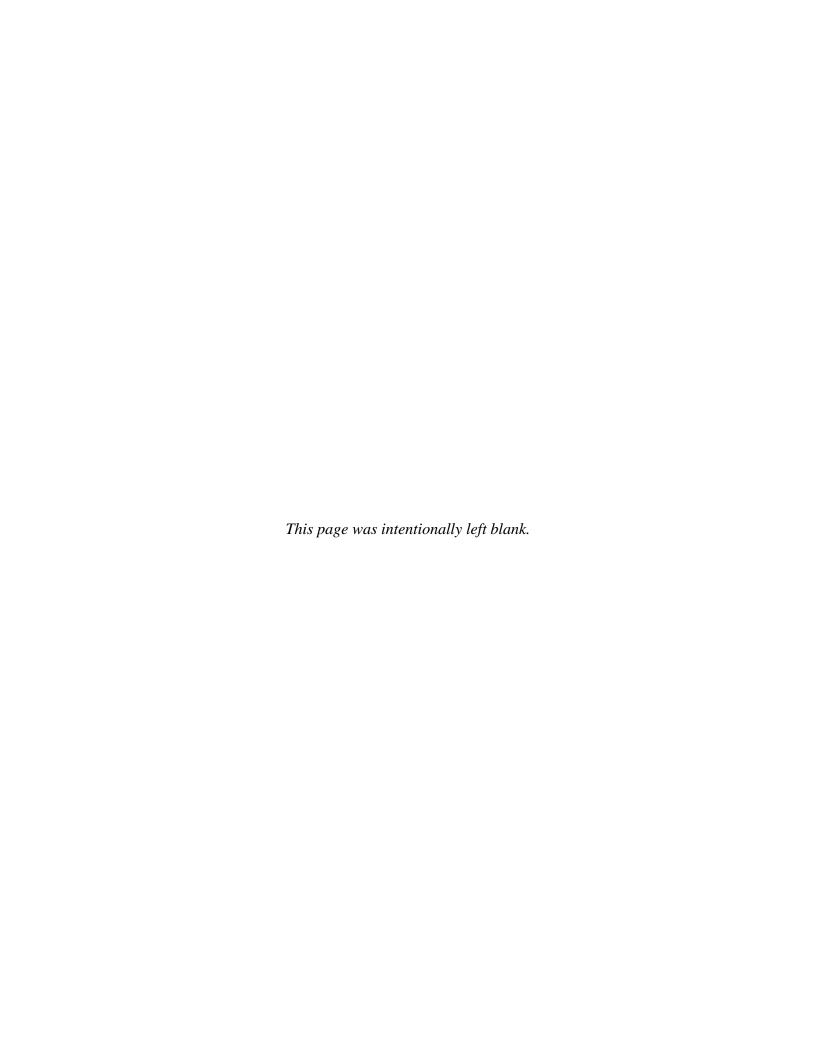


Table 3.1
Applicable or Relevant and Appropriate Requirements and Standards To Be Considered

		ARAR		Applicability to Proposed
ARAR	Legal Citation	Class/TBC	Requirement Synopsis	Remedies
Chemical Specific ARAR	S			
A. Water				
Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs)	40 CFR §§ 141.11, 141.61 and 141.62	Relevant and Appropriate	MCLs are enforceable standards for public drinking water supply systems which have at least 15 service connections or are used by at least 25 persons.	These requirements are not directly applicable since groundwater in the vicinity of the Site is not used as private drinking water supply. However, since groundwater at the Site is located within a Class II-A aquifer, which is a potential source of drinking water, the MCLs have been incorporated into the Preliminary Remedial Goals that were developed for the Site groundwater.
Clean Water Act (CWA): National Pollutant Discharge Elimination System (NPDES) Requirements	Clean Water Act, Section 402: 33 U.S.C. §1342, 40 CFR Parts 122-125	Applicable	NPDES Permit Equivalence will need to be established for any surface water discharges from any groundwater extraction and treatment or stormwater outfalls.	The substantive provisions of these requirements are applicable to any portion of the remedy that may affect the water quality in the nearby Towamencin and Wissahickon Creeks. Sediment and erosion control features will need to be implemented before start of intrusive construction activities.
Pennsylvania Water Quality Standards	25 Pa. Code § 93	Relevant and Appropriate	These are specific water quality criteria established pursuant to Section 304 of the CWA. These provisions set the concentrations of pollutants that are allowable to levels that preserve human health based on water and fish ingestion and to preserve aquatic life. Ambient water quality criteria may be relevant and appropriate to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) cleanups based on uses of a water body.	The discharge of treated groundwater would be required to meet the guidelines established for protection of aquatic life.

Table 3.1 (continued) Applicable or Relevant and Appropriate Requirements and Standards To Be Considered

		ARAR		Annligability to Duanged
ARAR	Local Citation	Class/TBC	Daguinament Cymansis	Applicability to Proposed Remedies
	Legal Citation	Class/ I bC	Requirement Synopsis	Remedies
Location-Specific ARARs				
Preservation of Historical and Archeological Data Act (or Archeological and Historic Preservation Act of 1974)	16 U.S.C.§ 469 – 469c.2	Applicable	Requires that Federal agencies take action to recover, protect, and preserve any significant scientific, prehistorical, historical, or archeological data that may be irreparably lost or destroyed as a result of the alteration of terrain caused by Federal activities.	U.S. Environmental Protection Agency (EPA) does not currently have any information that there are any significant scientific, prehistorical, historical, or archeological data at the Site. If EPA discovers that such data are present at the Site, actions will be taken to comply with the substantive requirements of this act.
The National Historic Preservation Act and regulations 16 U.S.C. §470; 36 CFR Part 800		Applicable	Requires that Federal agency actions avoid adverse effects in historic properties.	EPA does not currently have any information that there are historic properties at the Site. If a determination is made that there are historic properties on or near the Site, action will be taken to mitigate any adverse effects on those properties resulting from the remedial activities.
Action-Specific ARARs/T	BCs			
A. Water				
Pennsylvania Clean Streams Law	35 P. S. § 691.1; 25 Pa. Code §§ 16.1, 16.24, 16.31 – 16.33, 16.41, 16.51 and 16.101-102	Applicable	The objective of this statute is to reclaim and restore polluted streams. The law provides for the protection of streams and water quality control. This statute may be applicable to remedial alternatives that require the discharge of water/waste, and/or the cleanup of contaminated streams.	Any groundwater treatment alternative that involves the discharge of treated water will be required to comply with the substantive requirements of these discharge standards.

Table 3.1 (continued)
Applicable or Relevant and Appropriate Requirements and Standards To Be Considered

		ARAR		
ARAR	Legal Citation	Class/TBC	Requirement Synopsis	Applicability to Proposed Remedies
CWA	33 USC § 1342 40 CFR §§ 122.2, 122.4, 122.5, 122.21, 122.26, 122.29, 122.41, 122.43 – 122.45, 122.47,122.48 (All of these sections, except for 122.47, are incorporated by reference into Pennsylvania's regulation by 25 Pa. Code § 92.2.)	Relevant and Appropriate	Establishes effluent limitations for discharges to waters of Pennsylvania and the United States.	The groundwater treatment alternative that involves the discharge of treated water will be required to comply with the substantive requirements of these discharge standards.
Pennsylvania National Pollutant Discharge Elimination System Requirements	25 Pa. Code §§ 92.2, 92.3, 92.7, 92.31, 92.41, 92.51, 92.55, 92.57, 92.73, 93.6, 93.7 and 95.2			
SDWA Underground Injection Control (UIC) Regulations	40 CFR §§ 144.1– 144.55; 144.79-144.84; 146.1-1.6.10; 146.51- 146.73; 147.1951, 147.1952, 147.1955.	Relevant and Appropriate	Provides requirements for underground injection control permitting based on the federal program promulgated under Part C of the Safe Drinking Water Act.	The substantive requirements of these regulations will be followed for any remedy that involves the injection of materials into the subsurface.
Water Well Driller License Act	32 P.S. §645.1 et. seq.; 17 Pa. Code §§47.1 – 47.8	Applicable	Sets forth requirements for the licensing of water well drillers, prevention of pollution of underground waters, submittal of well construction records, and well abandonment notification.	The substantive requirements of these regulations will be followed for any remedy that involves the installation or abandonment of a well, or the injection of materials into an existing well.
Storm Water Management Act	33 U.S.C. § 402; 40 CFR 122.21; P.L. 864; 32 P.S. § 680.1 et seq.; 25 Pa. Code Chapters 92 and 102	Applicable	Requires implementation of storm water control measures to prevent injury to health, safety, or property.	Storm water controls will be implemented and maintained during construction of the remedy

Table 3.1 (continued)
Applicable or Relevant and Appropriate Requirements and Standards To Be Considered

ARAR	Legal Citation	ARAR Class/TBC	Requirement Synopsis	Applicability to Proposed Remedies
EPA Groundwater Remedy Completion Strategy	EPA Office of Solid Waste and Emergency Response (OSWER) Directive 9200.2-144. May 12, 2014	To Be Considered	Presents EPA's recommendations for evaluating Superfund groundwater remedy performance and making decisions to help facilitate achievement of RAOs and associated cleanup levels.	This guidance will be used to evaluate remedy performance and achievement of RAOs.
EPA Guidance for Evaluating Completion of Groundwater Restoration Remedial Action	EPA OSWER Directive 9355.0-129. November 25, 2013	To Be Considered	Presents EPA's recommendations for evaluating Superfund groundwater remedy performance and making decisions to help facilitate achievement of RAOs and associated cleanup levels.	This guidance will be used to evaluate remedy performance and achievement of RAOs.
B. Soil				
Erosion and Sediment Control	25 Pa. Code §§102.4(b)(1), 102.11, 102.22	Applicable	Identifies erosion and sediment control requirements and criteria for activities involving land clearing, grading and other earth disturbances and establishes erosion and sediment control criteria.	These regulations apply to construction activities at the Site that disturb the ground surface and would be applicable if capping, excavation, or well installation is required.
C. Wastes		1		
Resource Conservation and Recovery Act (RCRA) Pennsylvania Hazardous Waste Management Regulations	25 Pa. Code §§ 262a.34 (which incorporates by reference 40 CFR § 262.34), 264a.173, 40 CFR § 262.34 (accumulation time and requirements), 40 CFR § 264.171-175 (containers)	Relevant and Appropriate	These provisions govern the accumulation time for hazardous wastes and management of containers.	These requirements must be followed for any groundwater treatment remedy that generates hazardous sludge.
Municipal Waste Handling	25 Pa. Code, Article VIII	Applicable	These provisions govern the handling and disposal of municipal wastes.	These provisions are applicable to any remedy that will result in the generation of municipal waste upon implementation.
Residual Waste Handling	25 Pa. Code, Article IX	Applicable	These provisions govern the handling and disposal of residual wastes.	These provisions are applicable to any remedy that will result in the generation of residual wastes upon implementation.

Table 3.1 (continued) Applicable or Relevant and Appropriate Requirements and Standards To Be Considered

ARAR	Legal Citation	ARAR Class/TBC	Requirement Synopsis	Applicability to Proposed Remedies
D. Air	U			
Fugitive Air Emissions	40 CFR § 50.6 – 50.7; 25 Pa Code §§ 123.1– 123.2	Applicable	Establishes the fugitive dust regulation for particulate matter.	Any construction and/or excavation activities will comply with the substantive requirements of these regulations.
National Emissions Standards for Hazardous Air Pollutants	25 Pa Code §§ 124.1– 124.3 40 CFR Part 61	Applicable	Establishes the hazardous air pollutant discharge regulation.	Any construction and/or excavation activities as well as any treatment alternative that would result in the emission of Site contaminants to the air will comply with the substantive requirements of these regulations.
Construction, Modification, Reactivation, and Operation of Sources	25 Pa Code §§ 127.1 et seq.	Applicable	Establishes the requirements for the use of best available technology on new air pollutant emissions sources.	Any construction and/or excavation activities as well as any treatment alternative that would result in the emission of Site contaminants to the air will comply with the substantive requirements of these regulations.
Visible Emissions	25 Pa Code § 123.41	Applicable	Establishes opacity limits for visible air emissions.	Emissions from any excavation/ construction will comply with the substantive requirements of these requirements.

Table 4.1
Rationale For Selection of Contaminants of Concern

Receptor	Exposure Scenario	Cancer Risk ¹	Hazard Index (HI) ¹	Risk Driver(s)
Adult resident	Current exposure, Well R21	Evaluated as lifetime exposure	5 (immune system and heart HIs > 1)	TCE
Child resident	Current exposure, Well R21	Evaluated as lifetime exposure	9 (immune system and heart HIs > 1)	TCE
Adult and child resident	Current exposure, Well R21	6.00E-05	Not applicable (evaluated individually by age)	None (risks within target range)
Adult resident	Current exposure, Well R22	Evaluated as lifetime exposure	20 (kidney, immune system, and heart HIs > 1)	TCE and cis-1,2-DCE
Child resident	Current exposure, Well R22	Evaluated as lifetime exposure	40 (kidney, immune system, and heart HIs > 1)	TCE and cis-1,2-DCE
Adult and child resident	Current exposure, Well R22	3.00E-04	Not applicable (evaluated individually by age)	PCE and TCE
Adult resident	Current exposure, Well R24	Evaluated as lifetime exposure	0.8	None (HI does not exceed 1)
Child resident	Current exposure, Well R24	Evaluated as lifetime exposure	2 (skin and vascular HIs > 1)	Arsenic
Adult and child resident	Current exposure, Well R24	2.00E-04	Not applicable (evaluated individually by age)	Arsenic
Adult resident	Current exposure, Well R27	Evaluated as lifetime exposure	2	None (all target organ HIs ≤ 1)
Child resident	Current exposure, Well R27	Evaluated as lifetime exposure	7 (blood, skin, and vascular HIs > 1)	Arsenic, antimony, iron, and zinc
Adult and child resident	Current exposure, Well R27	2.00E-04	Not applicable (evaluated individually by age)	Arsenic
Adult worker	Current/future, production well water	3.00E-05	7 (immune system and heart HIs > 1)	TCE
Adult, recreational user	Wissahickon Creek	1.00E-05	0.04	None (risks and hazards within target ranges)
Child, recreational user	Wissahickon Creek	1.00E-05	0.1	None (risks and hazards within target ranges)
Adult, recreational user	Towamencin Creek	4.00E-06	0.02	None (risks and hazards within target ranges)
Child, recreational user	Towamencin Creek	4.00E-06	0.08	None (risks and hazards within target ranges)
Adult resident	North plume	Evaluated as lifetime exposure	20 (heart and immune system HIs > 1)	TCE and cobalt
Child resident	North plume	Evaluated as lifetime exposure	40 (blood, kidney, skin, vascular, heart, and immune system HIs > 1)	Antimony, cobalt, cis-1,2-DCE, barium, arsenic, TCE,
Adult and child resident	North plume	9.00E-04	Not applicable (evaluated individually by age)	PCE, TCE, arsenic, chromium
Adult resident	South plume	Evaluated as lifetime exposure	20 (heart and immune system HIs > 1)	TCE and cobalt
Child resident	South plume	Evaluated as lifetime exposure	40 (blood, kidney, heart, thyroid, and immune system HIs > 1)	Antimony, cobalt, iron, cis-1,2-DCE, TCE,
Adult and child resident	South plume	6.00E-04	Not applicable (evaluated individually by age)	Carbon tetrachloride, PCE, TCE, arsenic, chromium

Note

¹ Only the results for the reasonable maximum exposure (RME) scenarios were used to identify COCs. The RME scenarios are more conservative than the central tendency scenarios.

Table 4.2 Groundwater Preliminary Remediation Goals

Chemical	PRG	Basis
Tetrachloroethene	5 μg/L	Drinking Water MCL
Trichloroethene	5 μg/L	Drinking Water MCL
cis-1,2-DCE	28.9 μg/L	Risk Based Child non- Cancer
Vinyl chloride	2 μg/L	Drinking Water MCL
Carbon tetrachloride	5 μg/L	Drinking Water MCL
Antimony	6 μg/L	Drinking Water MCL
Arsenic	10 μg/L	Drinking Water MCL
Barium	2,000 μg/L	Drinking Water MCL
Chromium	100 μg/L	Drinking Water MCL
Cobalt	6 μg/L	Tapwater RSL
Iron	14,000 μg/L	Tapwater RSL
Lead	15 μg/L	Drinking Water MCL
Zinc	6,000 μg/L	Tapwater RSL

Notes:

 $\mu g/L - micrograms \ per \ liter$

PRG – preliminary remediation goal

MCL – maximum contaminant level

COC – contaminant of concern

RSL – regional screening level (November 2017)

General Response Action	Alternative	Summary of Alternative	Effectiveness ⁽¹⁾	Implementability ⁽¹⁾	Screening Conclusion
No Action	Alternative 1: No Action	 Take no remedial action. Contaminated groundwater will be subject to natural conditions and processes. Five-year reviews will be conducted. 	Rank = 5 Does not eliminate human health risks. Fails to meet identified ARARs.	Rank = 1 No construction or operations and maintenance (O&M) required. Five-year reviews required.	Retained as a baseline for other alternatives
Treatment	Alternative 2: Monitored Natural Attenuation and ICs	 ICs⁽²⁾ Monitored natural attenuation throughout the plumes. Annual monitoring of groundwater quality. Five-year reviews will be conducted. 	Rank = 4 Limits the allowable future use of groundwater. Unlikely to meet PRGs in a reasonable time frame. Allows compliance with most, but not all, identified ARARs.	Rank = 2 Monitoring of groundwater required until PRGs are achieved. Five-year reviews required.	Eliminated from further analysis for failure to meet ARARs
Treatment and Removal	Alternative 3: Groundwater Extraction Treatment with Monitored Natural Attenuation, and ICs	 ICs⁽²⁾ Installation and operation of groundwater extraction system in highest contaminant concentration areas of plume. Monitored natural attenuation in the distal portions of the plumes. Annual monitoring of groundwater quality. Five-year reviews will be conducted. 	Rank = 2 Limits the allowable future use of groundwater until PRGs are achieved. Potentially addresses all Site contaminants. Potential for untreated areas to remain because of extraction difficulties. Potentially allows compliance with all identified ARARs.	Rank =3 Requires installation of treatment system(s) and extraction wells. Requires aquifer testing to optimize the extraction well placement. Existing infrastructure makes construction of GETS difficult. Requires O&M of the treatment system. Monitoring of groundwater required until PRGs are achieved. Five-year reviews required.	Retained for detailed analysis
Treatment and Removal	Alternative 4: In Situ Chemical Oxidation (ISCO) with Monitored Natural Attenuation and ICs	 ICs⁽²⁾; Oxidant injection in highest contaminant concentration areas of plume. Monitored natural attenuation in the distal portions of the plumes. Annual monitoring of groundwater quality. Five-year reviews will be conducted. 	Rank = 2 Limits the allowable future use of groundwater until PRGs are achieved. Addresses all Site contaminants. Potential for untreated areas to remain because of distribution difficulties. Potentially allows compliance with all identified ARARs.	Rank =3 Requires pilot studies, installation of injection points, and injection of oxidants and amendments Difficult to accurately inject amendments into fractured bedrock. Multiple rounds of oxidant injections likely needed to address potential contaminant rebound. Oxidant injection might reduce available anaerobic microbial community. Additional injection wells may be required. Monitoring of groundwater required until PRGs are achieved.	Retained for detailed analysis
Treatment and Removal	Alternative 5: Enhanced In Situ Bioremediation with Monitored Natural Attenuation and ICs	 ICs⁽²⁾; Electron donor and pH buffer injection to improve degradation of organic contaminants. Dehalococcoides inoculation. Monitored natural attenuation in the distal portions of the plumes. Annual monitoring of groundwater quality. Five-year reviews will be conducted. 	Rank = 2 Limits the allowable future use of groundwater until PRGs are achieved. Addresses all Site contaminants. Potential for untreated areas to remain because of distribution difficulties. Potentially allows compliance with all identified ARARs.	Rank =3 Requires injection of amendments and installation of injection points. Difficult to accurately inject amendments into fractured bedrock. Potential increase in groundwater metal concentrations from creating a reducing anaerobic environment. Success dependent on <i>Dehalococcoides</i> bacteria population growth. Additional injection wells required. Monitored natural attenuation would be used for the distal portions of the plume.	Retained for detailed analysis

Notes:

(1) Alternatives are ranked qualitatively on effectiveness and implementability. In terms of effectiveness, each alternative was ranked on a scale of 1 (complete destruction or removal of all Site contaminants) to 5 (no change in risks related to Site contamination). With regard to implementability, the alternatives were ranked on a scale of 1 (no construction or O&M required) to 5 (impossible to implement).

(2) ICs are part of all Alternatives except No Action. ICs include deed restrictions and access agreements.

Table 9.1 Cost Estimate

Alternative 3 - Groundwater Extraction and Treatment with Monitored Natural Attenuation and Land Use Controls Feasibility Study Report, OU3, North Penn Area 7, Montgomery County, PA

Phase Name	Year 1	Year 2	Year 3	Year 4		Year 5		Year 6-10		Year 11-15		/ear 16-20	Year 21-25	Year 26-30	Total
Remedial Action (RA)															
Construction of GETS	\$ 2,014,666	\$ 2,014,666													\$ 4,029,333
Installation of extraction wells	\$ 778,481														\$ 778,481
MW Installation	\$ 211,598														\$ 211,598
Oversight	\$ 598,156	\$ 598,156													\$ 1,196,312
Post RA Implementation															
Long-term monitoring	\$ 38,978	\$ 155,911	\$ 77,956	\$ 77,956	\$	77,956	\$	100,115	\$	100,115	\$	100,115	\$ 100,115	\$ 100,115	\$ 929,333
O&M	\$ 371,225	\$ 371,225	\$ 248,841	\$ 248,841	\$	248,841	\$	1,244,204	\$	1,244,204	\$	1,244,204	\$ 1,244,204	\$ 1,244,204	\$ 7,709,991
Long-term monitoring report		\$ 33,004	\$ 33,004	\$ 33,004	\$	33,004	\$	165,022	\$	165,022	\$	165,022	\$ 165,022	\$ 165,022	\$ 957,125
Five-Year Review					\$	41,803	\$	41,803	\$	41,803	\$	41,803	\$ 41,803	\$ 41,803	\$ 250,816
Subtotal	\$ 4,013,104	\$ 3,172,963	\$ 359,801	\$ 359,801	\$	401,604	\$	1,551,143	\$	1,551,143	\$	1,551,143	\$ 1,551,143	\$ 1,551,143	\$ 16,062,988
Escalated for Inflation*	\$ 4,013,104	\$ 3,220,557	\$ 370,676	\$ 376,236	\$	426,247	\$	1,720,539	\$	1,853,509	\$	1,996,756	\$ 2,151,073	\$ 2,317,317	\$ 18,446,014
Present Value Estimate*	\$ 4,013,104	\$ 2,550,420	\$ 302,582	\$ 287,028	\$	303,909	\$	1,007,668	\$	773,978	\$	594,484	\$ 456,616	\$ 350,722	\$ 10,640,511

^{*} A yearly inflation rate of

1.50% is used along with a 7% discount rate.

Table 9.2 Cost Estimate

Alternative 4 - In Situ Chemical Oxidation with Monitored Natural Attenuation and Land Use Controls Feasibility Study Report, OU3, North Penn Area 7, Montgomery County, PA

Phase Name	Year 1	Year 2	Year 3	Year 4		Year 5	Year 6-10		Year 11-15		Year 16-20	Year 21-25	Year 26-30	Total
Remedial Action (RA)														
Former Teleflex Facility	\$ 2,764,940			\$	440,076		\$	240,586						\$ 3,445,602
Former Ford Facility	\$ 2,416,781			\$	284,473		\$	146,319						\$ 2,847,574
Former Spra-Fin Facility		\$ 1,712,792		\$	301,638		\$	172,684						\$ 2,187,113
Oversight	\$ 253,066	\$ 253,066		\$	138,036		\$	115,030						\$ 759,198
MW Installation	\$ 211,598													\$ 211,598
Post RA Implementation														
Long-term monitoring	\$ 57,689	\$ 230,755	\$ 115,378	\$	115,378	\$ 115,378	\$	576,888	\$	146,893				\$ 1,358,357
Long-term monitoring report		\$ 33,004	\$ 33,004	\$	33,004	\$ 33,004	\$	165,022	\$	165,022				\$ 462,060
Five-Year Review						\$ 41,803	\$	41,803	\$	41,803				\$ 125,408
Subtotal	\$ 5,704,074	\$ 2,229,617	\$ 148,382	\$	1,312,606	\$ 190,185	\$	1,458,330	\$	353,717				\$ 11,396,911
Escalated for Inflation*	\$ 5,704,074	\$ 2,263,061	\$ 152,867	\$	1,372,563	\$ 201,855	\$	1,598,139	\$	424,504				\$ 11,717,063
Present Value Estimate*	\$ 5,704,074	\$ 1,603,482	\$ 124,785	\$	1,047,122	\$ 143,920	\$	989,130	\$	173,847				\$ 9,786,359

^{*} A yearly inflation rate of

1.50% is used along with a 7% discount rate.

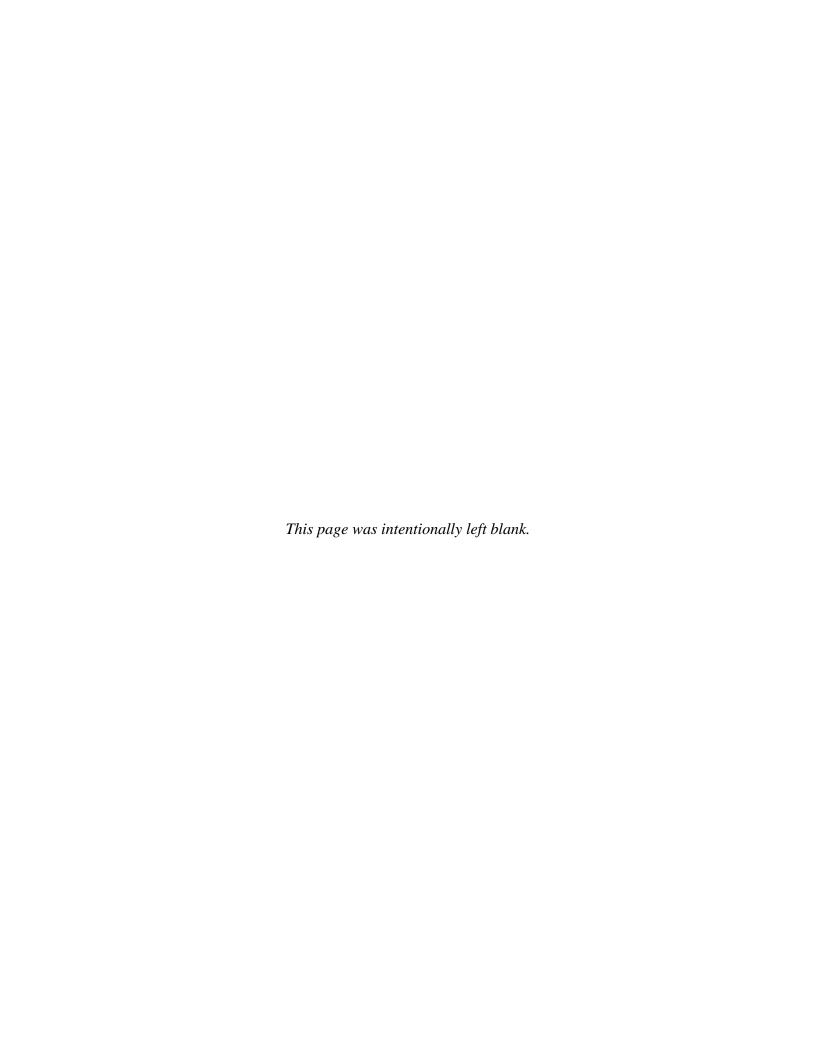
Table 9.3 Cost Estimate

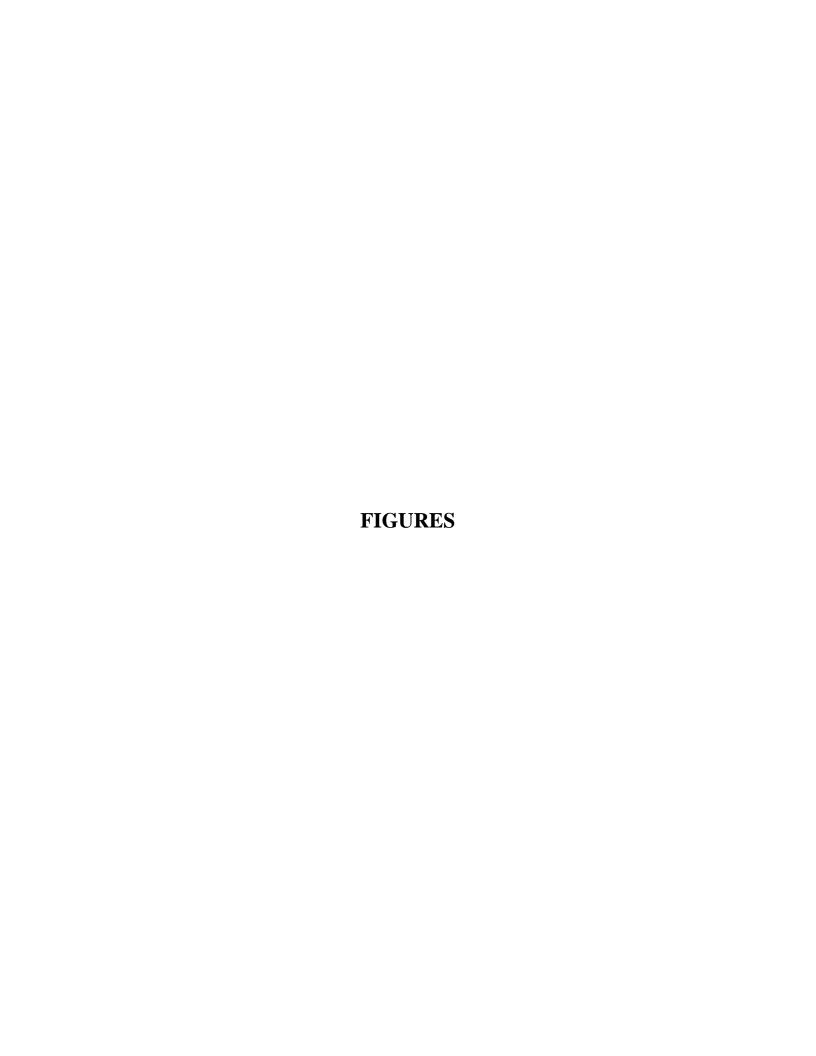
Alternative 5 - In Situ Bioremediation with Monitored Natural Attenuation and Land Use Controls Feasibility Study Report, OU3, North Penn Area 7, Montgomery County, PA

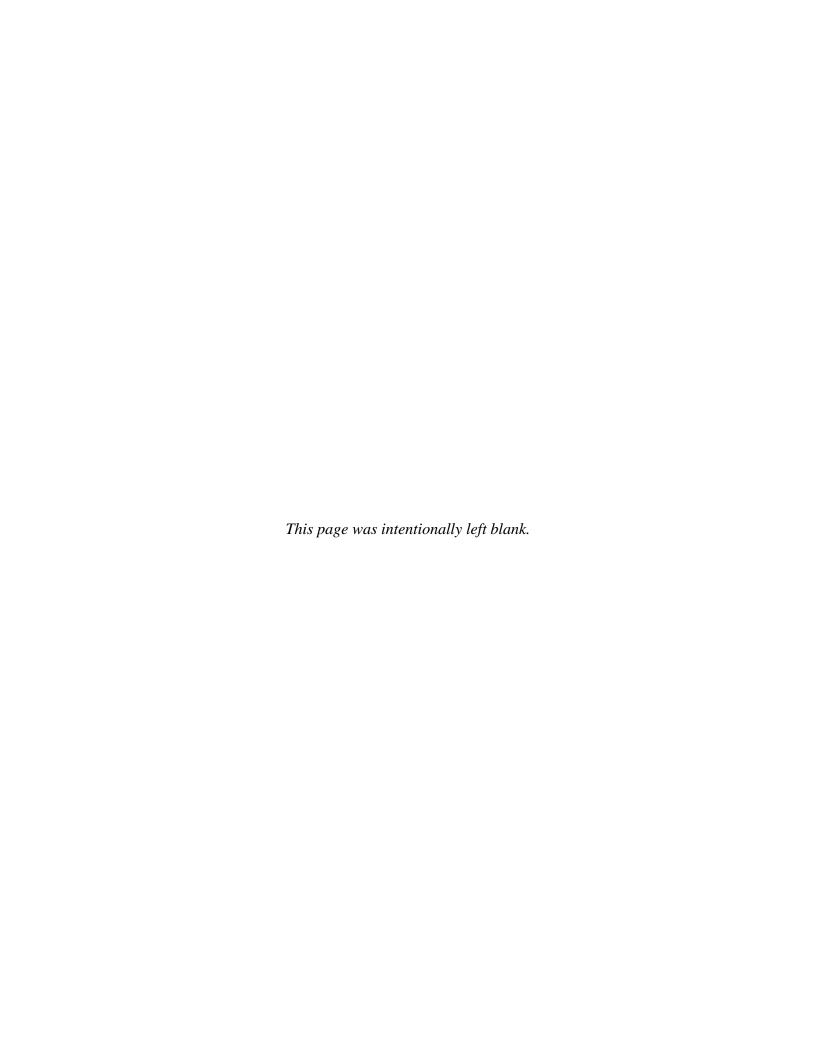
Phase Name	Year 1		Year 2		Year 3		Year 4		Year 5		Year 6-10		Year 11-15	Year 16-20	Year 21-25	Year 26-30	Total
Remedial Action (RA)																	
Former Teleflex Facility	\$	2,173,973					\$	292,617									\$ 2,466,589
Former Ford Facility			\$	2,100,843			\$	121,991									\$ 2,222,834
Former Spra-Fin Facility	\$	1,529,381					\$	208,203									\$ 1,737,584
Oversight	\$	253,066	\$	253,066			\$	138,036									\$ 644,168
MW Installation	\$	211,598															\$ 211,598
Post RA Implementation																	
Long-term monitoring	\$	57,689	\$	230,755	\$	115,378	\$	115,378	\$	77,956	\$	146,893					\$ 744,048
Long-term monitoring report			\$	33,004	\$	33,004	\$	33,004	\$	33,004	\$	165,022					\$ 297,039
Five-Year Review									\$	41,803	\$	41,803					\$ 83,605
Subtotal	\$	4,225,707	\$	2,617,669	\$	148,382	\$	909,228	\$	152,763	\$	353,717		-			\$ 8,407,465
Escalated for Inflation*	\$	4,225,707	\$	2,656,934	\$	152,867	\$	950,760	\$	162,137	\$	391,287					\$ 8,539,690
Present Value Estimate*	\$	4,225,707	\$	2,044,221	\$	124,785	\$	725,330	\$	115,601	\$	232,047					\$ 7,467,690

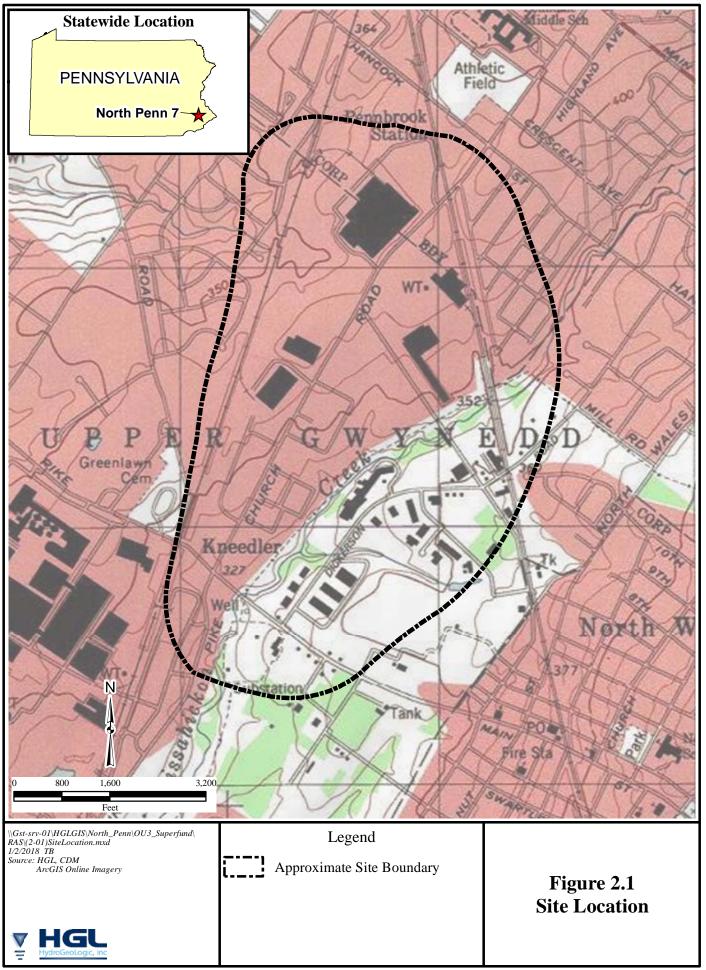
^{*} A yearly inflation rate of

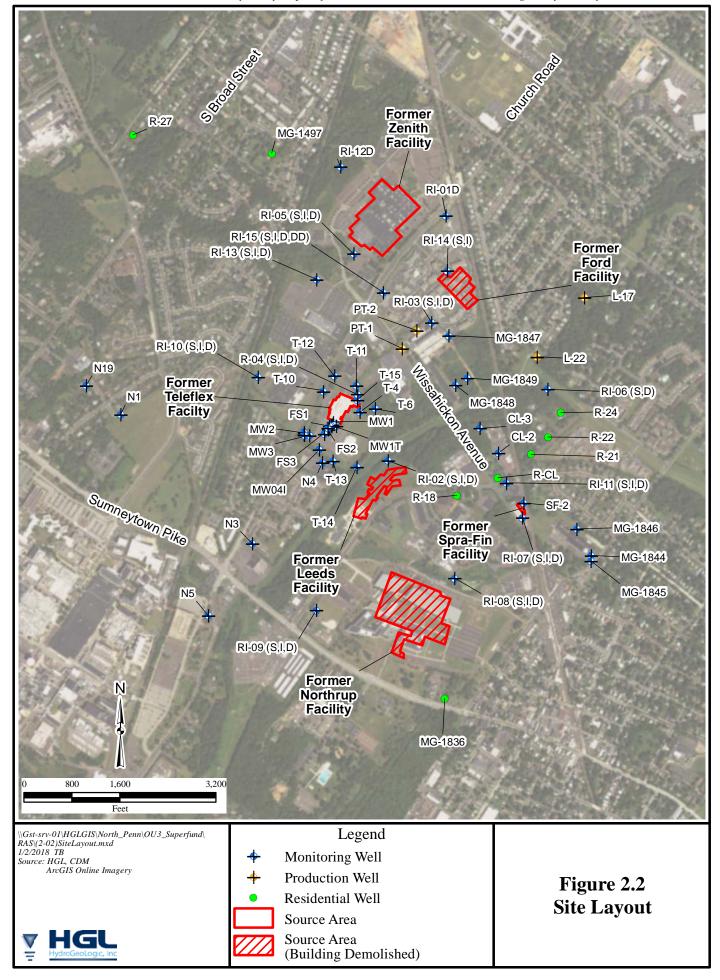
1.50% is used along with a 7% discount rate.

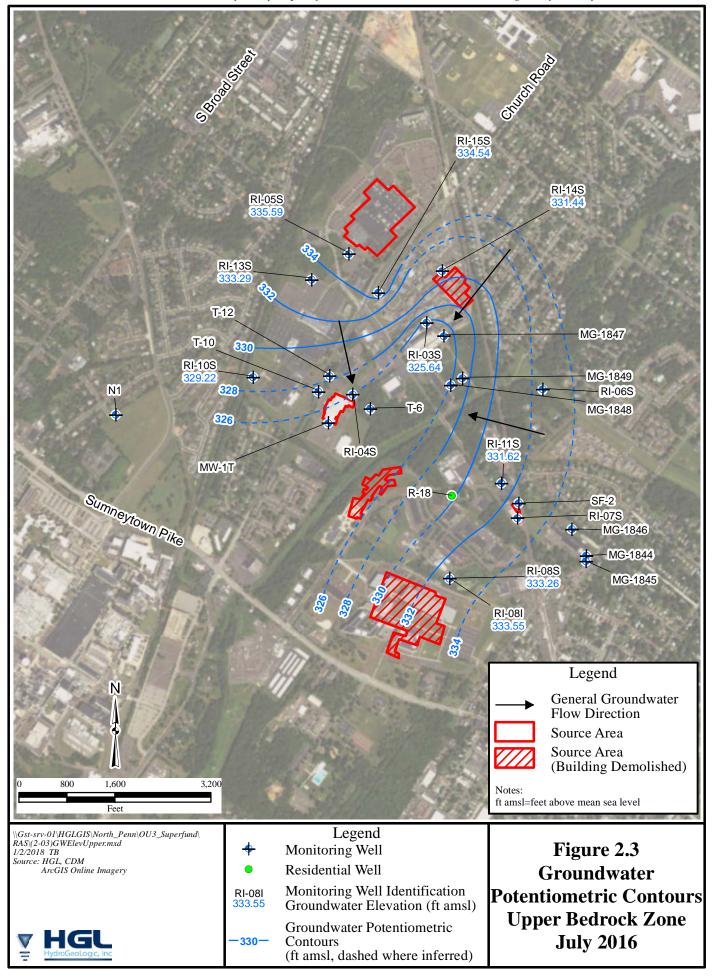


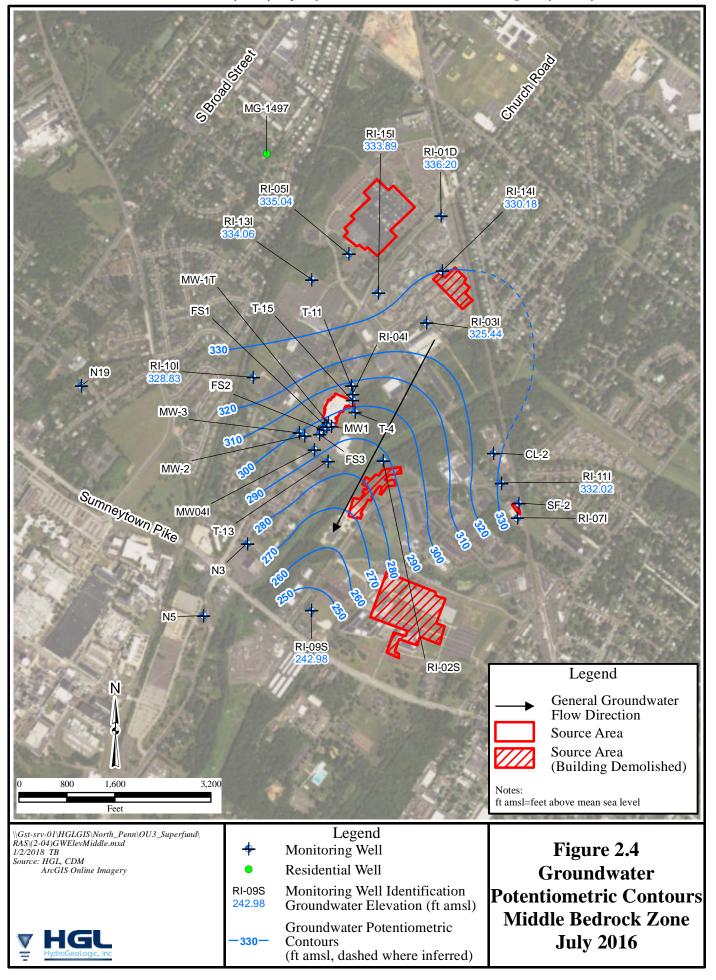


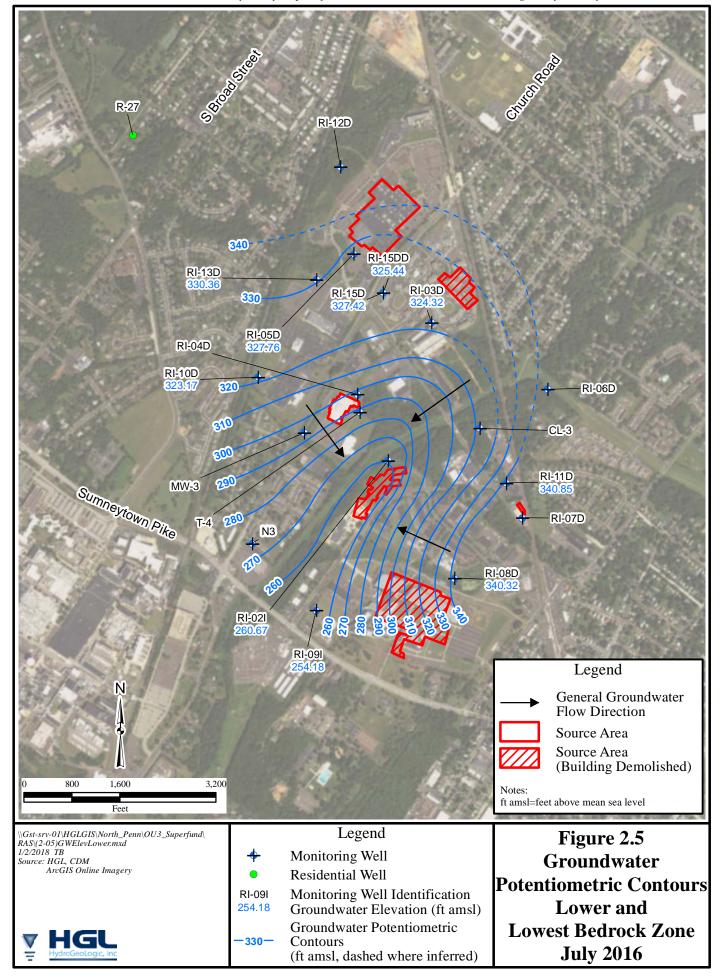


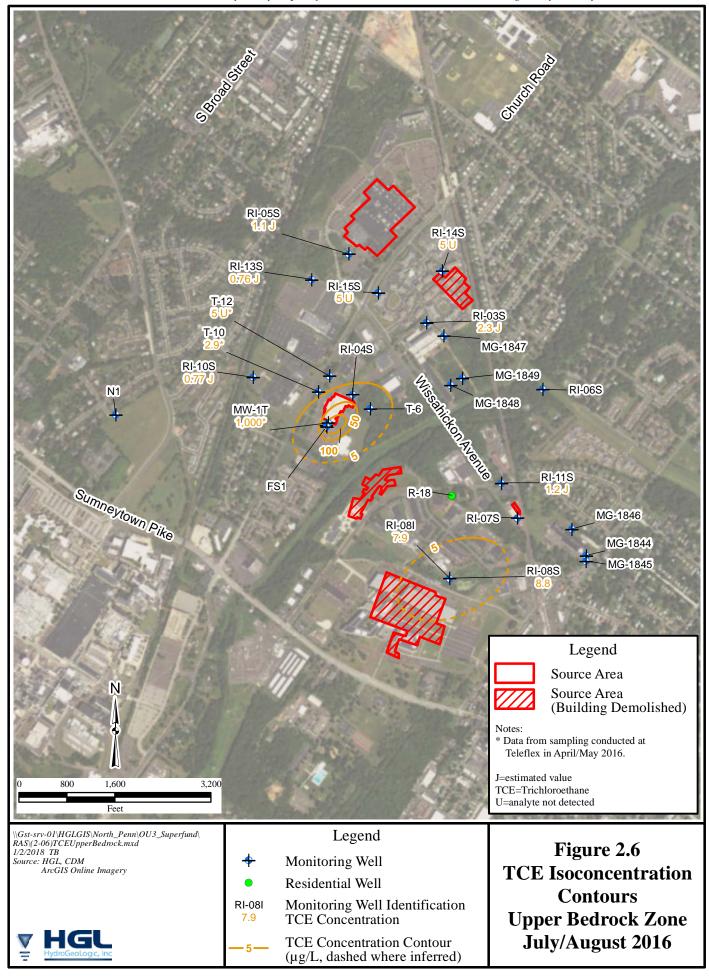


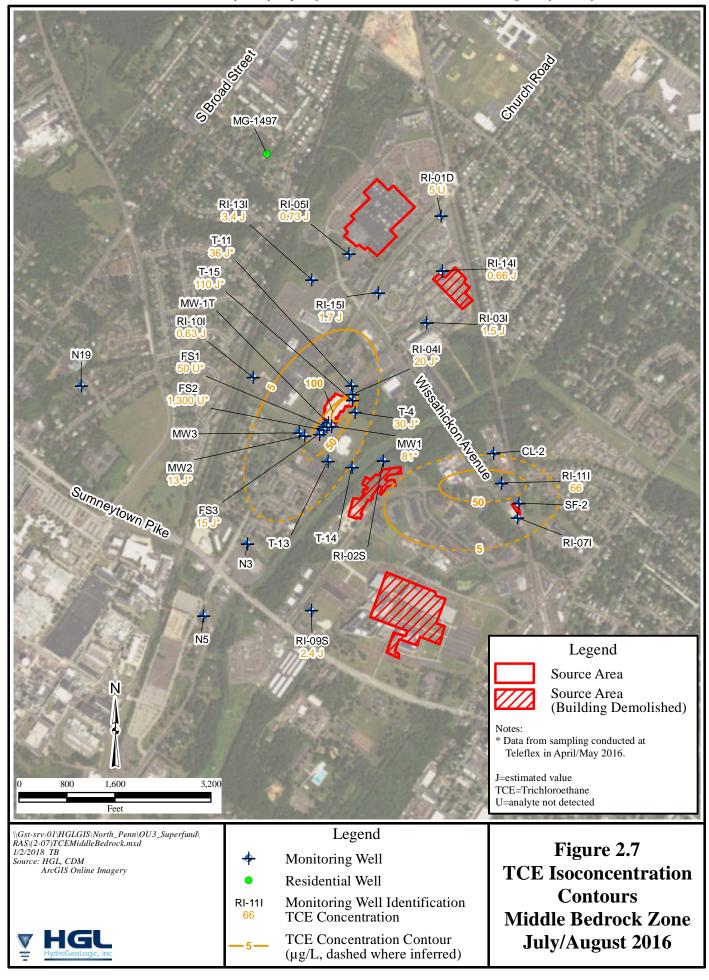


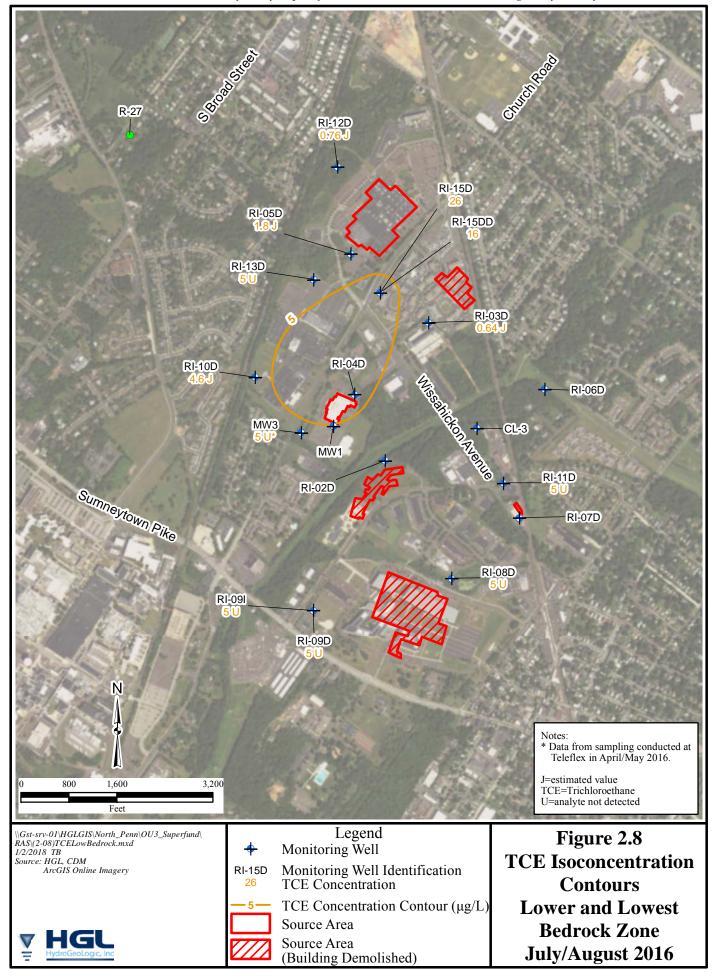


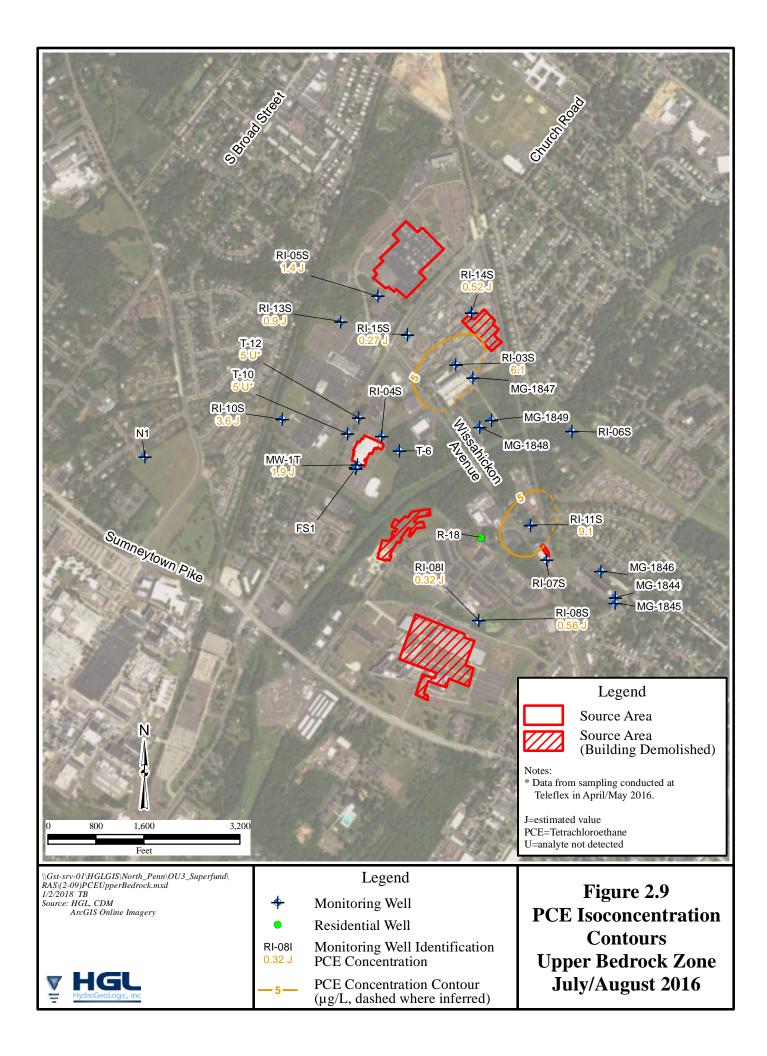


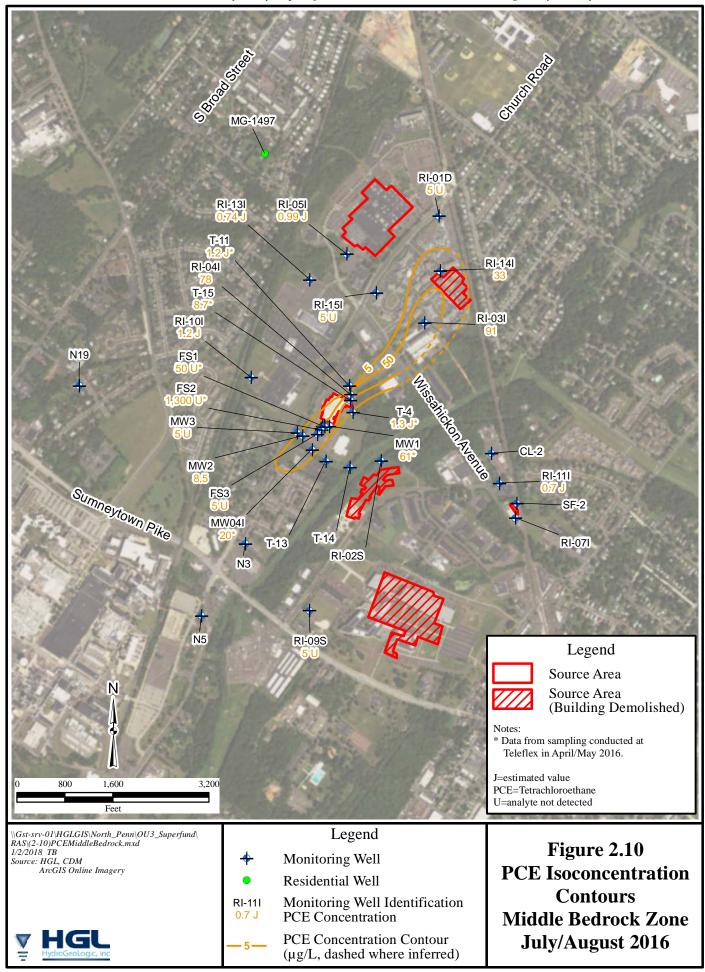


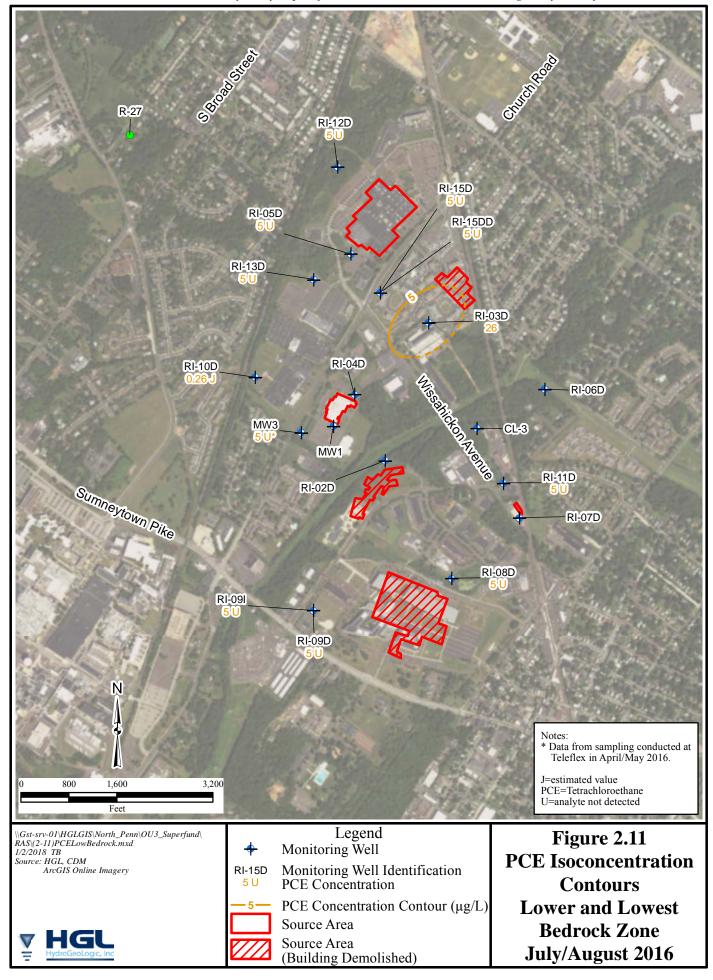


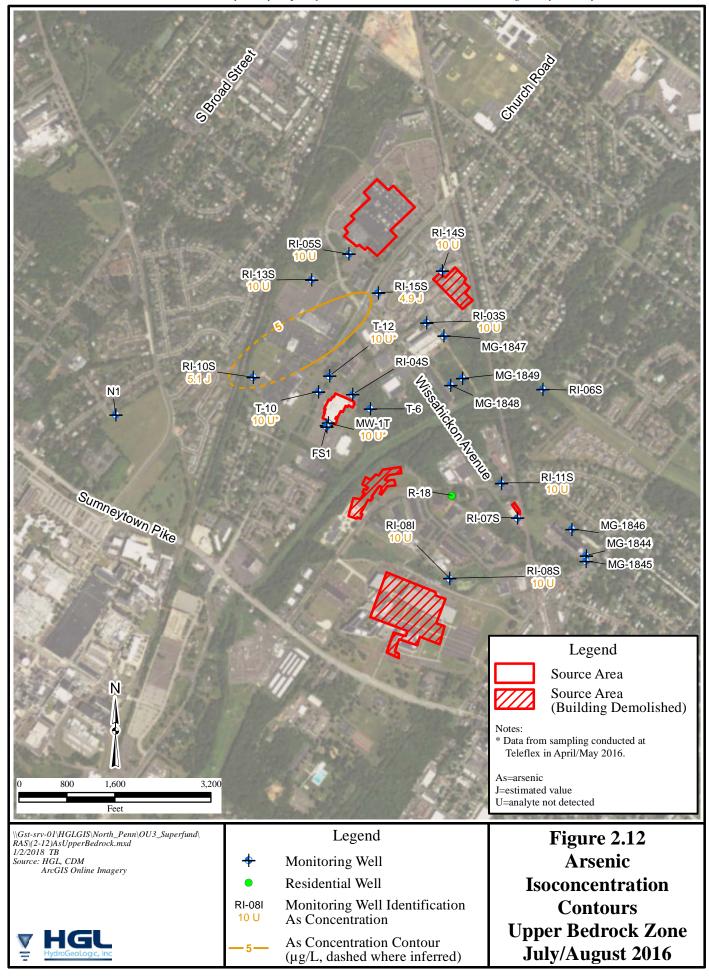


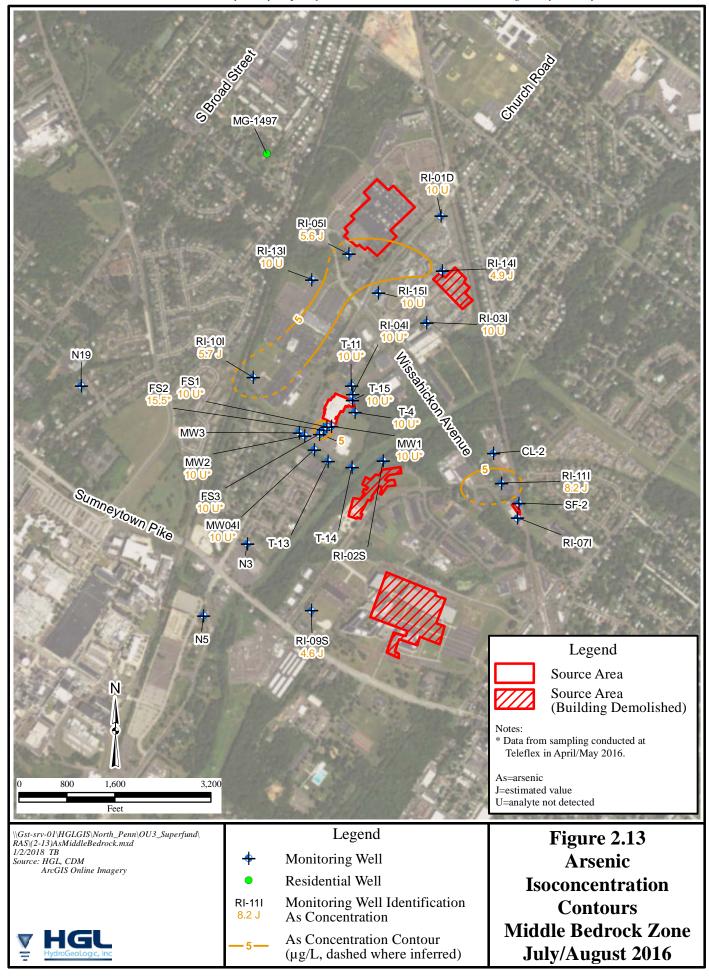


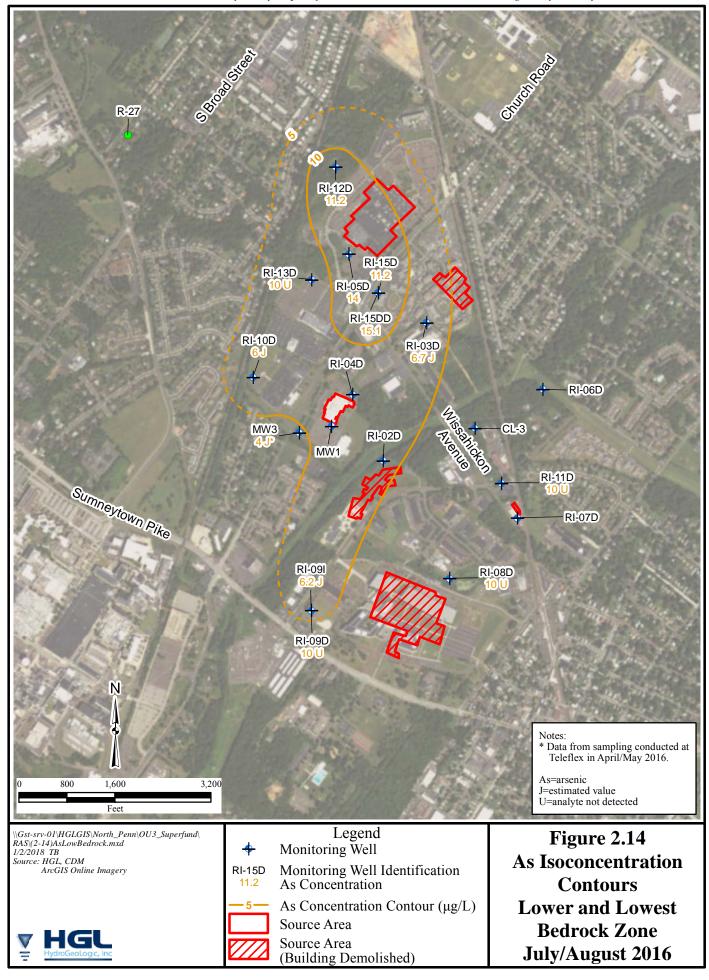


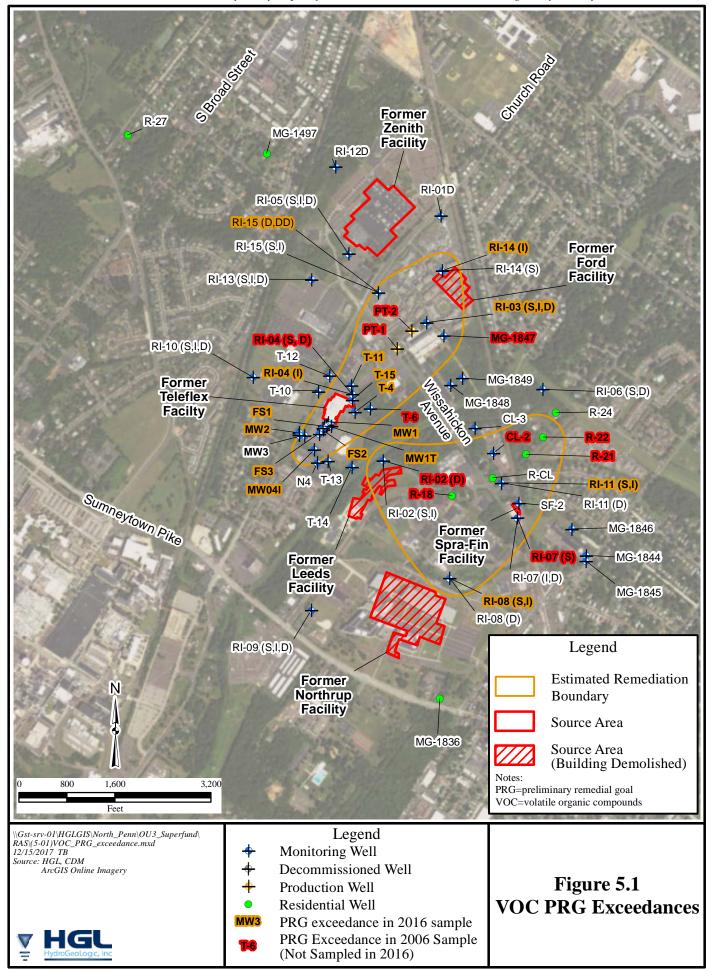


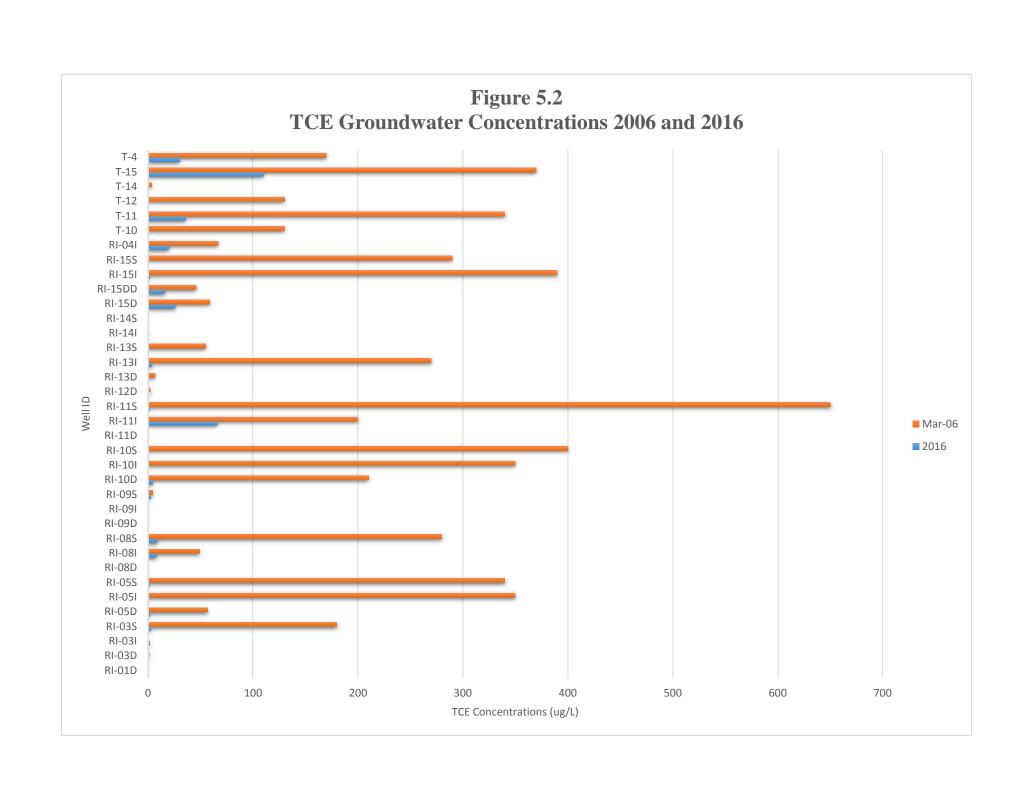


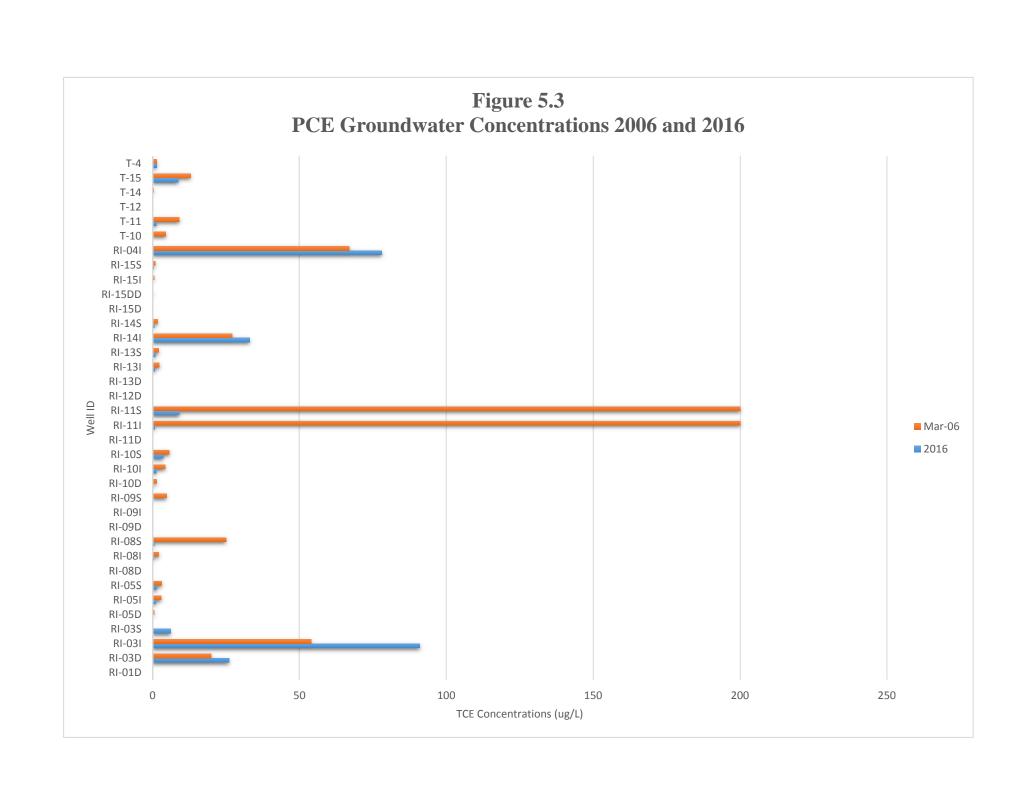


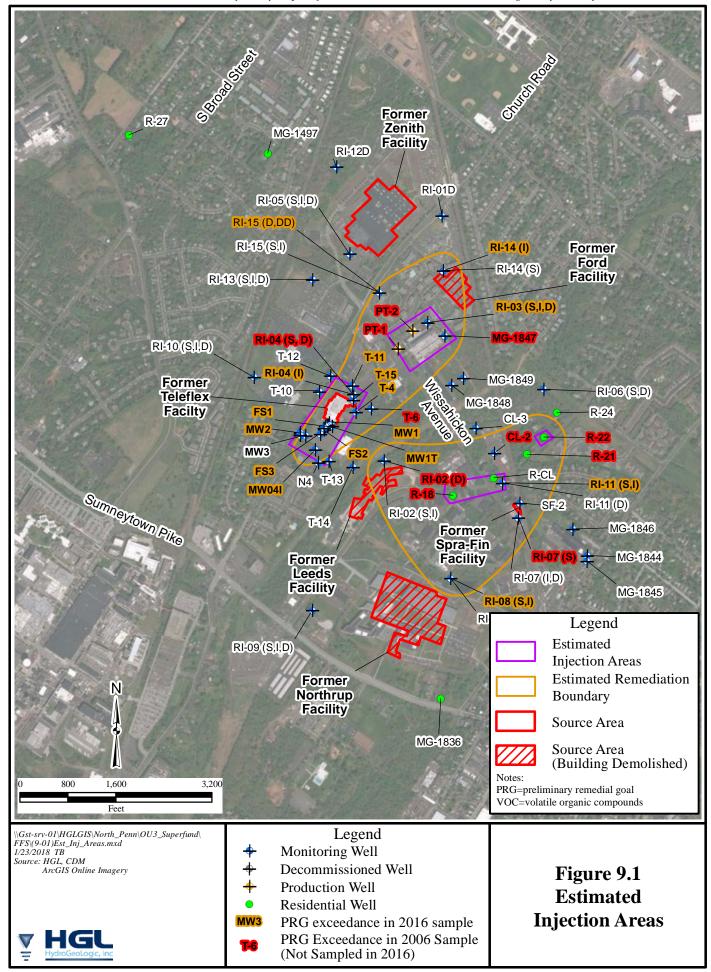












APPENDIX A

Historical Site Layout Figures

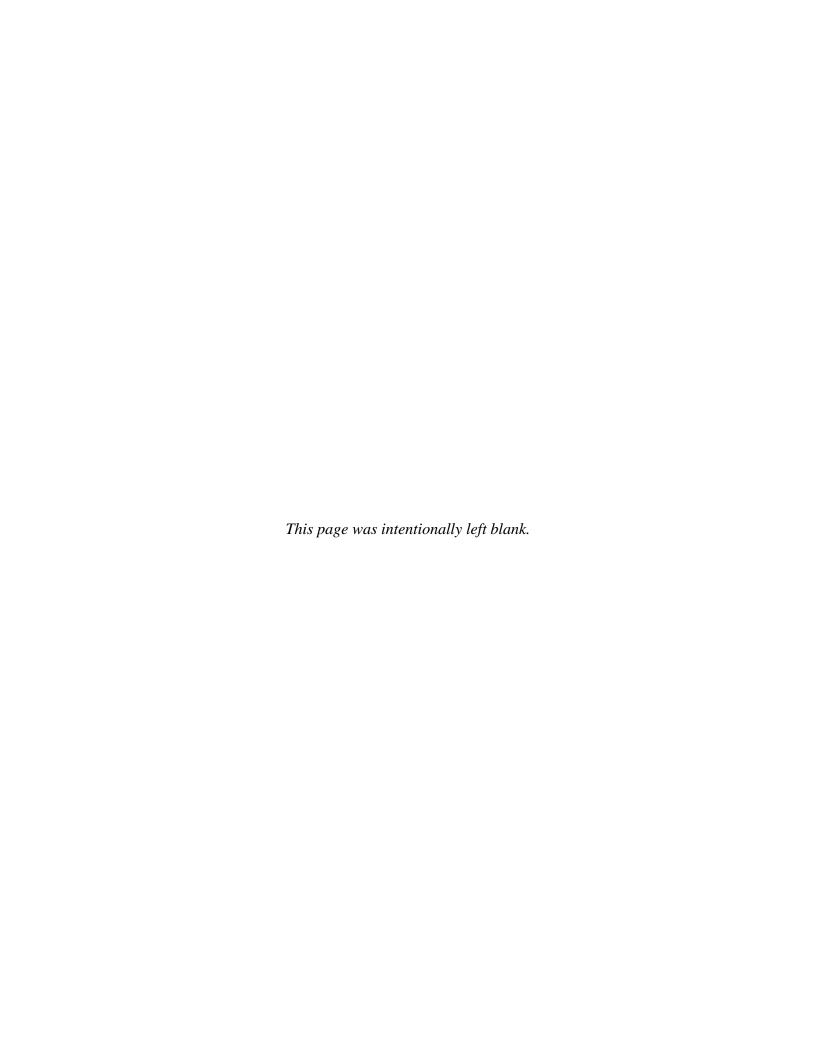
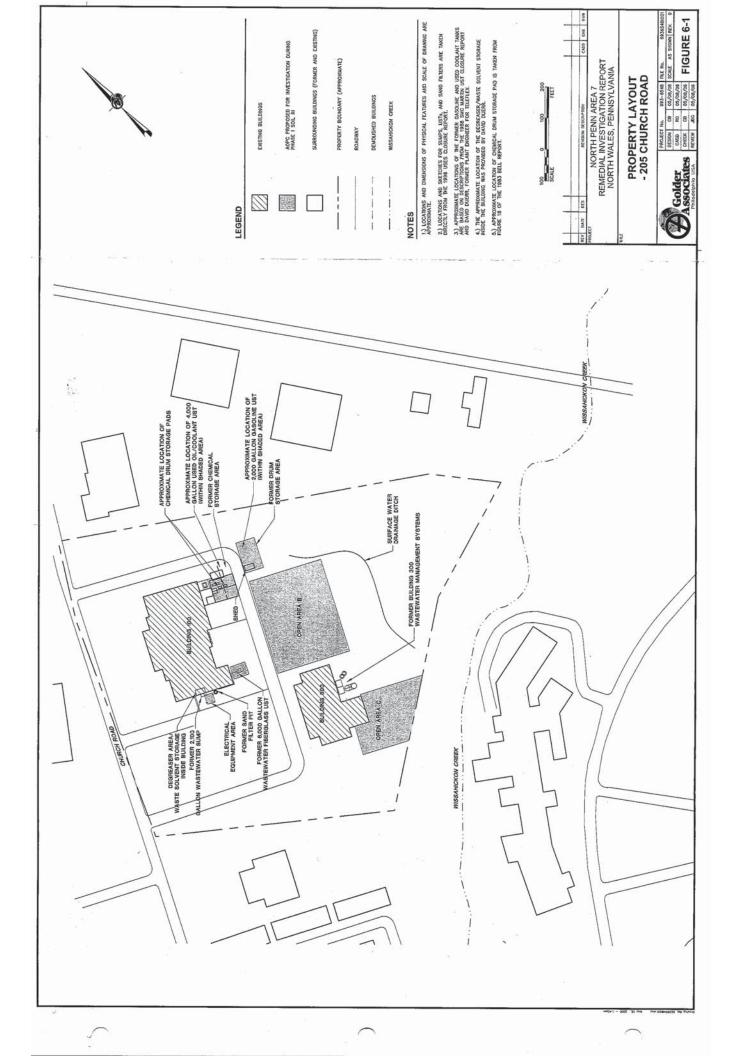
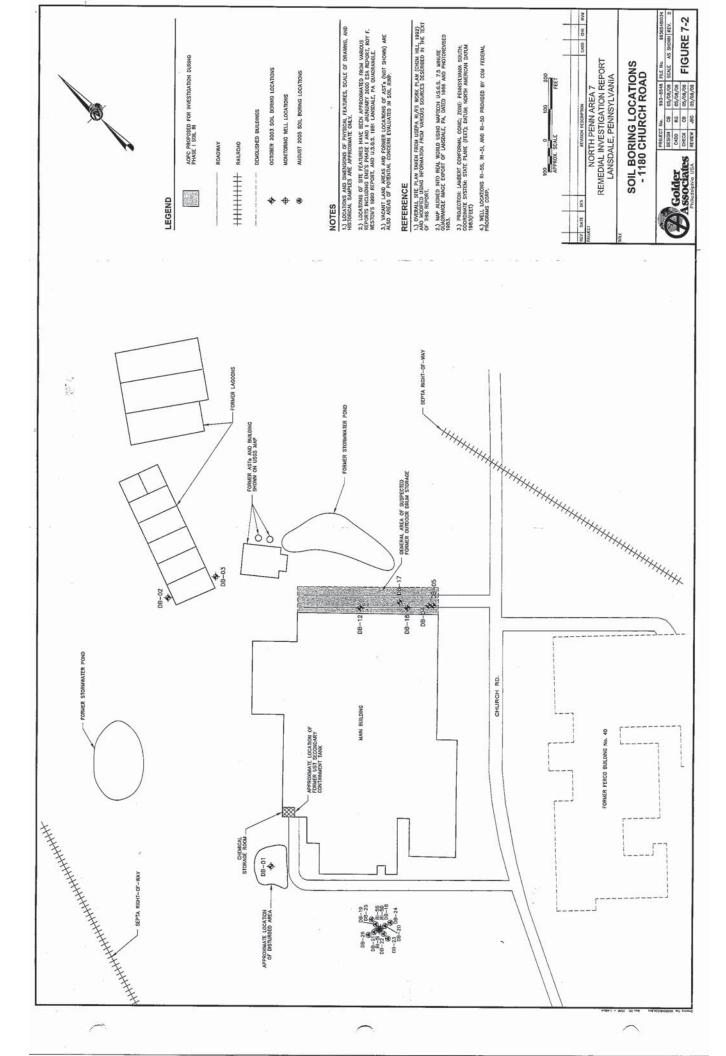
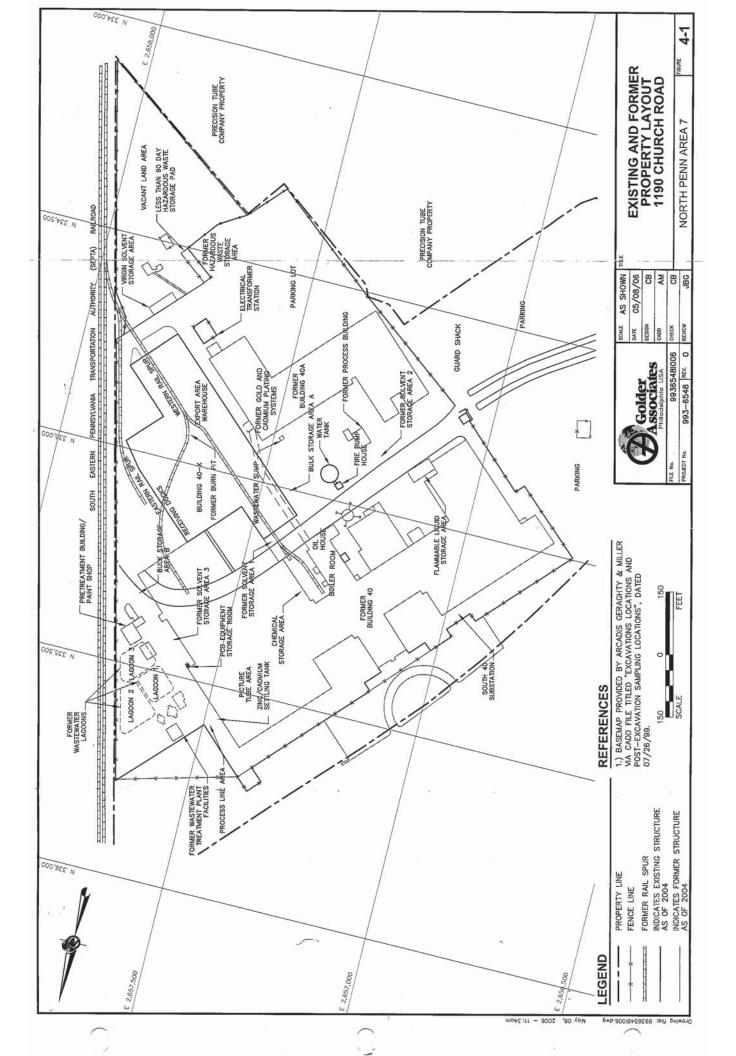


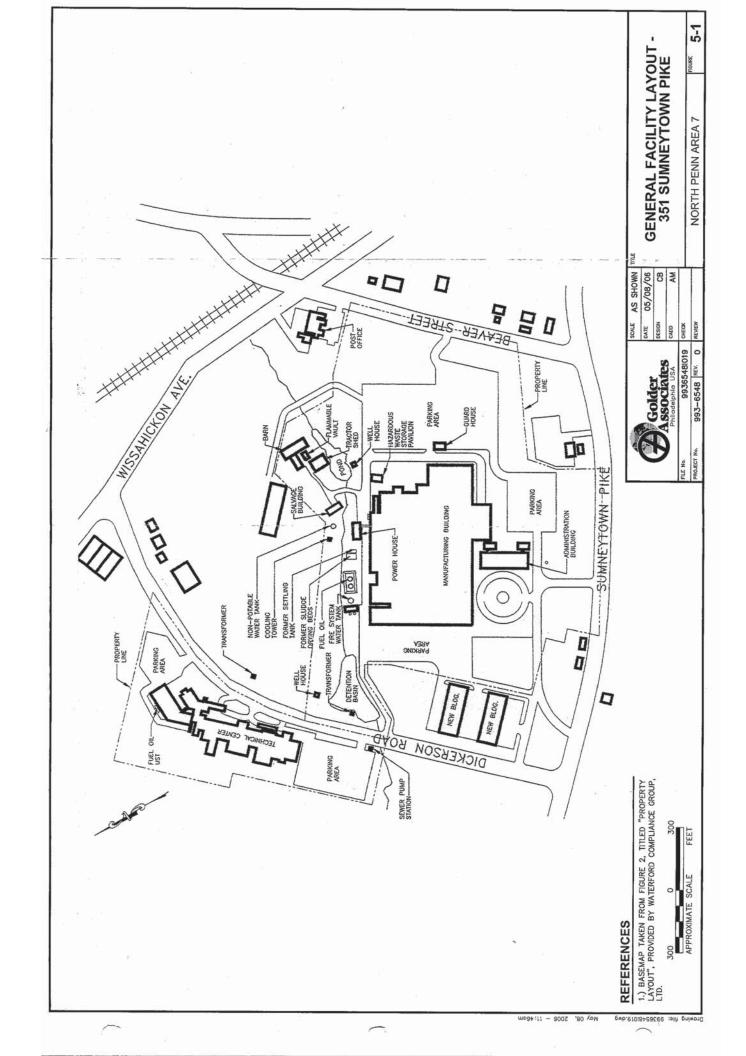
Figure List

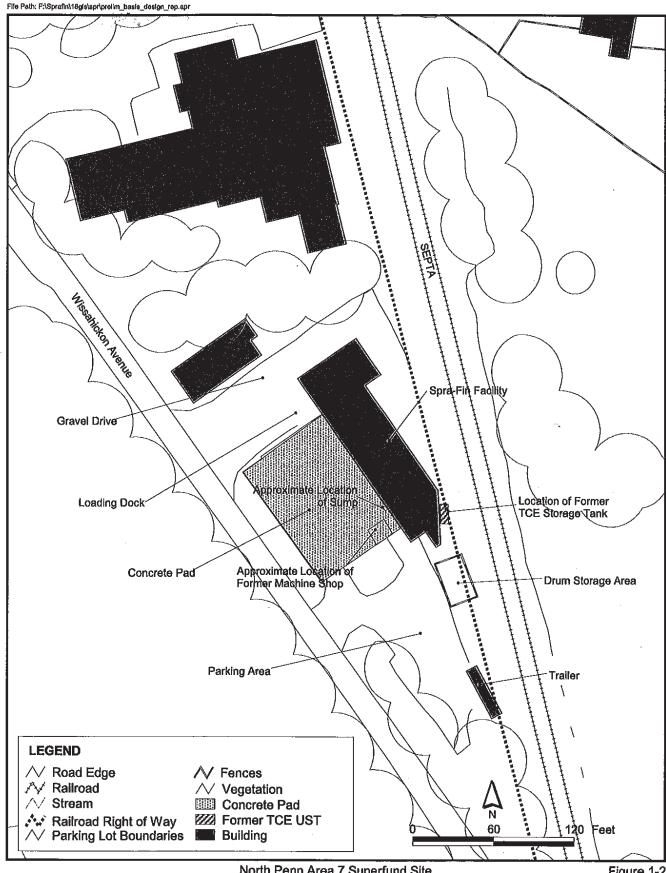
Source Area	Figure No.	Figure Title	Source				
Teleflex	Teleflex 6-1		Golder Associates Inc., 2006. Phase 1 Soil Remedial Investigation Report, North Penn Area 7 Superfund Site, Upper Gwynedd Township, PA, May, 2006.				
Zenith	7-2	Soil Boring Locations – 1180 Church Road	Golder Associates Inc., 2006. Phase 1 Soil Remedial Investigation Report, North Penn Area 7 Superfund Site, Upper Gwynedd Township, PA, May, 2006.				
Ford 4-1		Existing and Former Property Layout – 1190 Church Road	Golder Associates Inc., 2006. Phase 1 Soil Remedial Investigation Report, North Penn Area 7 Superfund Site, Upper Gwynedd Township, PA, May, 2006.				
Leeds & Northrup	5-1	General Facility Layout – 351 Sumneytown Pike	Golder Associates Inc., 2006. Phase 1 Soil Remedial Investigation Report, North Penn Area 7 Superfund Site, Upper Gwynedd Township, PA, May, 2006.				
Spra-Fin	1-2	Site Map	CDM Federal Programs Corporation (CDM). 2005. Pre-final (90%) Basis of Design Report, North Penn Area 7 Superfund Site, Upper Gwynedd Township, PA, September, 2005.				











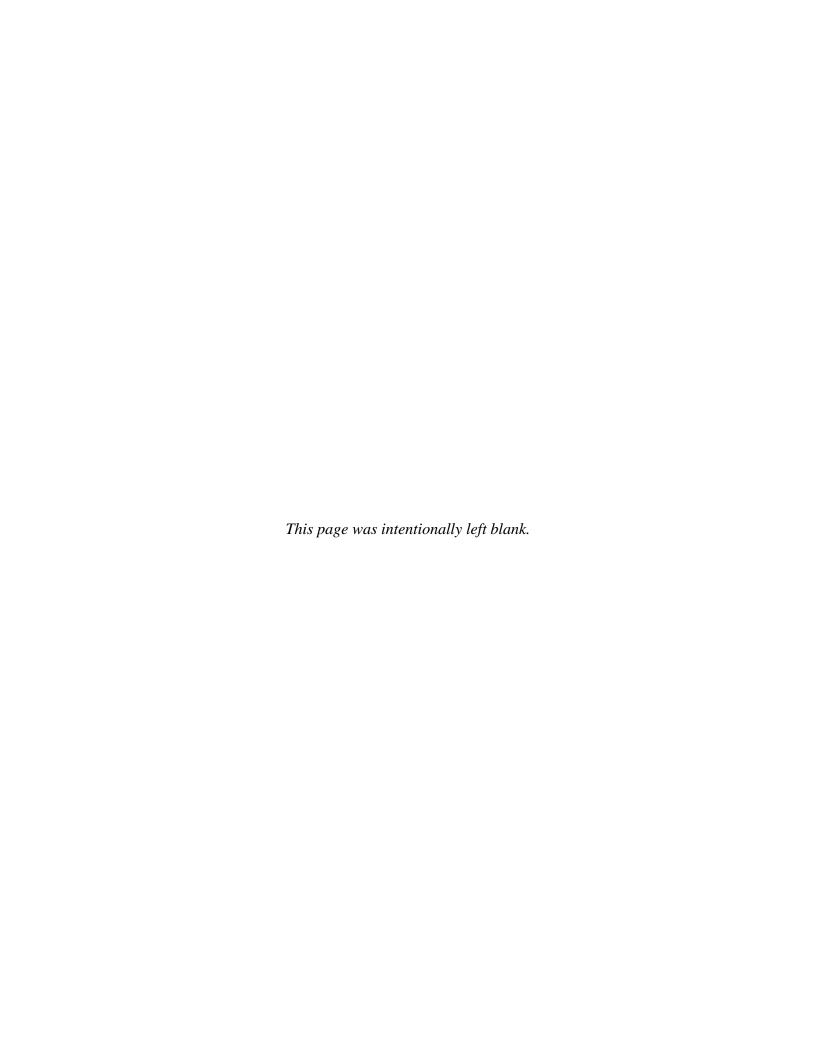
CDIV

North Penn Area 7 Superfund Site Operable Unit 2 (Spra-Fin Facility) Upper Gwynedd Township, Pennsylvania

Figure 1-2 Site Map

APPENDIX B

Detailed Cost Estimates



Assumptions
Assume two systems will be installed; one to treat the northern plume and one to treat the southern plume.
Each system would have multi-media bag filters, followed by an air stripper. The effluent from the stripper would be polished through a liquid GAC unit and a vapor GAC unit would be used to treat the contaminants from the air stripper.
Assume that the footprint of new building would be 30x 40 ft each.

If RACER did not provide cost estimates, vendor quotes or engineering estimates were used.

1800/324 12" Structural Slab on Grade 2	
National Strict	
33130012 4** Diameter Electric Automatic Bage Filter Unit 331306202 2** Stanlaines Steel Plinging, Schedule 40, Threaded, Includes Coupling 10** OC, Excludes Hangers ### 18020321 6** Structural Slab on Grade 18020321 6** Structural Slab on Grade 18020321 6** Structural Slab on Grade 18010204 Polywiny chloride pressure pipe, 2**, class 200, SDR 21, includes trenching to 3' deep 18010204 Polywiny chloride pressure pipe, 2**, class 200, SDR 21, includes trenching to 3' deep 18010204 Polywiny chloride pressure pipe, 2**, class 200, SDR 21, includes trenching to 3' deep 18010204 Polywiny chloride pressure pipe, 2**, class 200, SDR 21, includes trenching to 3' deep 18010204 Polywiny chloride pressure pipe, 2**, class 200, SDR 21, includes trenching to 3' deep 18010204 Polywiny chloride pressure pipe, 2**, class 200, SDR 21, includes trenching to 3' deep 18010204 Polywiny chloride pressure pipe, 2**, class 200, SDR 21, includes trenching to 3' deep 18010204 Polywiny chloride pressure pipe, 2**, class 200, SDR 21, includes trenching to 3' deep 18010204 Polywiny chloride pressure pipe, 2**, class 200, SDR 21, includes trenching to 3' deep 18010204 Polywiny chloride pressure pipe, 2**, class 200, SDR 21, includes trenching to 3' deep 18010204 Polywiny chloride pressure pipe, 2**, class 200, SDR 21, includes trenching to 3' deep 18010204 Polywiny chloride pressure pipe, 2**, class 200, SDR 21, includes trenching to 3' deep 18010204 Polywiny chloride pressure pipe, 2**, class 200, SDR 21, includes trenching to 3' deep 18010204 Polywiny chloride pressure pipe, 2**, class 200, SDR 21, includes trenching to 3' deep 18010204 Polywiny chloride pressure pipe, 2**, class 200, SDR 21, includes trenching to 3' deep 18010204 Polywiny chloride pressure pipe, 2**, class 200, SDR 21, includes trenching to 3' deep 18010204 Polywiny chloride pressure pipe, 2**, class 200, SDR 21, includes trenching to 3' deep 18010204 Polywiny chloride pressure pipe, 2**, class 200, SDR 21, class 200, SDR 21, class 200, SDR 21, class	
18/00/321 6" Structural Slab on Grade 70 SF \$ 3.67 \$ 4.33 \$ 0.008 \$ 1,959.54	
1820/331 S'tructural Slab on Grade 70 5 3 36 3.0 5 3.67 5 3.37 5 3.37 5 3.37 5 3.37 5 3.37 5 3.37 5 3.37 3.3	
1910/0204 Polyvinyl chloride pressure pipe, 2", class 200, SDR 21, includes trenching to 3' deep 100 F S 1.21 S 3.3, 366.00 S 3,764.62 S S S S S 3,770.62 S S 5,770.62 S 5,770.62 S 5,770.62 S 5,770.62 S S 5,770.62 S 5,770.62 S 5,770.62 S 5,770.62 S S 5,770.62 S 5,770.62 S 5,770.62 S 5,770.62 S S 5,770.62 S 5,770.62 S 5,770.62 S 5,770.62 S S 5,770.62 S 5,770.62 S 5,770.62 S 5,770.62 S S 5,770.62 S 5,770.62 S 5,770.62 S 5,770.62 S S 5,770.62 S 5,770.62 S 5,770.62 S 5,770.62 S S 5,770.62 S 5,770.62 S 5,770.62 S 5,770.62 S S 5,770.62 S 5,770.62 S 5,770.62 S 5,770.62 S S 5,770.62 S 5,770.62 S 5,770.62 S 5,770.62 S S 5,770.62 S 5,770.62 S 5,770.62 S 5,770.62 S S 5,770.62 S 5,770.62 S 5,770.62 S 5,770.62 S S 5,770.62 S 5,770.62 S 5,770.62 S 5,770.62 S S 5,770.62 S 5,770.62 S 5,770.62 S 5,770.62 S S S S S S S S S	
Air Stripper	
Air Stripper	
Sali Sali Substitution	
Salition Sout Sou	
18020324 12" Structural Slab on Grade 18020322 8" Structural Slab on Grade 1	
180/03/24 12" Structural Slab on Grade 50 SF 5 7.29 5 6.03 5 0.19 5 5 5 5.49 5	
Second Processes of the process gas purification, carbon adsorption, vapor phase, modular carbon adsorbers	
Second Processing Registry Second Process 1 EA 19.21 10.469 10.71	
Liquid GAC Liquid GAC Liquid GAC S3131971 1 KW Hazardous Air Heatter 1 EA \$ 1,249,48 \$ 1,674,3 \$ 5 - \$ - \$ 1,416.91 33131980 Dual Bed,500 CFM Series/1000 CFM Parallel, 1000 Lb Fill each 33131980 Dual Bed,500 CFM Series/1000 CFM Parallel, 1000 Lb Fill each 33131980 Dual Bed,500 CFM Series/1000 CFM Parallel, 1000 Lb Fill each 33131980 Dual Bed,500 CFM Series/1000 CFM Parallel, 1000 Lb Fill each 3313190 Dual Bed,500 CFM Series/1000 CFM Parallel, 1000 Lb Fill each 33131009 Pressure Gauge 1 EA \$ 1,195,47 \$ 394,45 \$ - \$ 5 - \$ 1,589,92 331310209 Pressure Gauge 1 8003322 8" Structural Slab on Grade 33132028 S" Structural Slab on Grade 33132029 Modular liquid-phase activated carbon, Dual Bed, 2 - 4" Diameter, 65 GPM Series, 130 GPM Parallel, 2,000 Lb Each 33132012 15 GPM, 15 HP, Transfer Pump with Motor, Valves, Piping 1 Frenching Piping 1 7030257 Cat 215, 1.0 CY, Soil, Shallow, Trenching, Excludes Dewatering 2 149 BCY 2 2 7 5 5 1.63 3 7 04 CY 3 7 7 8 1.63 3 8 11.33 5 11.41 7 8 1.416.91 3 7 1.416.91 3 7 1.416.91 3 11.510.43 5 7 7 40 5 - \$ 1,208.12 5 - \$ 1,208.12 5 - \$ 3,208.12 5 - \$ 3,208.12 5 - \$ 3,208.12 5 - \$ 3,208.12 5 - \$ 3,208.12 5 - \$ 3,208.12 5 - \$ 3,208.12 5 - \$ 3,208.12 5 - \$ 3,208.12 5 - \$ 3,208.12 5 - \$ 3,208.12 5 - \$ 1,300.36 5	
Salianger 1 KW Hazardous Air Heater 1 EA \$ 811.33 \$ 216.79 \$ - \$ \$ 1,028.12	
33131980 Dual Bed,500 CFM Series/1000 CFM Parallel, 1000 Lb Fill each 33131980 Dual Bed,500 CFM Series/1000 CFM Parallel, 1000 Lb Fill each 3313109 1,000 CFM Blower System, 5" Pressure, 1 1/2 HP 1 EA	
33310109 1,000 CFM Blower System, 5" Pressure, 1 1/2 HP	
Salado Pressure Gauge 2 EA \$ 109.89 \$ 87.20 \$ - \$ \$ 394.19	
18020322 8" Structural Slab on Grade 35 SF 5 .5.4 5 .2.3 5 .0.17 5 - 5 382.62	
Vapor GAC 33132029 Modular liquid-phase activated carbon, Dual Bed, 2 - 4' Diameter, 65 GPM Series, 130 GPM Parallel, 2,000 Lb Each 1 EA \$ 4,968.78 \$ 19,503.44 \$ 2,029.63 \$ 5 - \$ 133,003.68 \$ 33290121 50 GPM, 1.5 HP, Transfer Pump with Motor, Valves, Piping 1 EA \$ 2,990.09 \$ 2,084.99 \$ - \$ 5 - \$ 5,075.89 \$ \$ 150,003.68 \$ 10,000 \$ 10,0	
33290121 50 GPM, 1.5 HP, Transfer Pump with Motor, Valves, Piping 1 EA \$ 2,990.9 \$ 2,084.9 \$ \$ - \$ \$ 5,075.89 Subtotal \$ 138,462.19 Trenching 17030257 Cat 215, 1.0 CY, Soil, Shallow, Trenching, Excludes Sheeting, Excludes Dewatering 149 BCY \$ - \$ \$ 0.87 \$ 0.36 \$ - \$ 182.25 Trenching 17030415 On-Site Backfill for Large Excavations, Includes Compaction 201.15 ECY \$ - \$ 1.02 \$ 0.88 \$ 0.04 \$ 390.72 Piping 17030418 Backfill with Crushed Stone 37.04 CY \$ 27.75 \$ 1.53 \$ 0.79 \$ - \$ 1,113.98 Northern 17030501 Compaction unique St Piffs, walls behind vibration plate 37.04 CY \$ 27.75 \$ 1.53 \$ 0.79 \$ - \$ 1,114.17	
17030257 Cat 215, 1.0 CY, Soil, Shallow, Trenching, Excludes Dewatering 149 BCY 5 - 5 1.02 5 182.25	
17030257 Cat 215, 1.0 CY, Soil, Shallow, Trenching, Excludes Dewatering 149 BCY \$ - \$ 0.87 \$ 0.36 \$ - \$ 182.25	
Irenching	
Piping 17030415 On-Site Backfill for Large Excavations, Includes Compaction 201.15 ECY \$ - \$ 1.02 \$ 0.88 \$ 0.04 \$ 390.72	
Northern 17/309418 Backfill with Crushed Stone 37,044 CY \$ 27,75 \$ 1.53 \$ 0.79 \$ - \$ 1,115.98 Northern 17/309501 (Comparing purposed a 18" wide 8" lifts walk behind vibrating plate 37,045 CY \$ - \$ 20 \$ 0.75 \$ - \$ 1.14.17	
riulie	
33260211 4" Stainless Steel, Schedule 40, Connection Piping 750 LF \$ 75.00 \$ 31.32 \$ - \$ - \$ 9,740.00 Subtotal \$ 81.541.12	
Subtotal \$ 81,541.12 - 17030257 Cat 215, 1.0 CY, Soil, Shallow, Trenching, Excludes Sheeting, Excludes Dewatering 192 BCY \$ - \$ 0.87 \$ 0.36 \$ - \$ 234.85	
Trenching 17030425 Cat 2.15, LDCT, 5011, Fall calliantow, Tericuling, Excludes Dewalering 122 BCT 5 - 5 0.67 5 0.50 5 - 5 294-65 1 17030415 On-Site Backfill for Large Excavations, Includes Compaction 433 ECY 5 - 5 1.02 5 0.88 5 0.04 5 841.08	
7PIping 17030418 Backfill with Crushed Stone 52.12 CV \$ 27.75 \$ 1.53 \$ 0.79 \$ - \$ 1.567.51	
Southern 17030501 Compaction subgrade 18" wide 8" lifts walk behind vibrating plate 53.12 FCV \$ - \$ 20.1 \$ 0.17 \$ - \$ 160.65	
Plume 133260114 ("Stainless Steek, Schedule 40, Connection Piping 1500 1500 1500 1500 1500 1500 1500 150	
Subtotal \$ 162,284.08	
33430101 Equipment Building 10' Ceiling, Built-Up Roof, Concrete Block Exterior 2400 SF \$ - \$ - \$ 208.45 \$ 500,272.80	
33430401 PLC, 160 I/O points, 6K logic memory, 2 EA \$ 266,174.09 \$153,957.17 \$ - \$ - \$ 840,262.51	
Building Leasing/Purchasing of Land 1 acres \$ 250,000.00 \$ 250,000.00 Average price of the area for agriculture/industri	ial lands
Construction Short-Term ICs 1 LS \$ 50,000.00 \$ - \$ - \$ 50,000.00 Engineering Judgment	
Permits 1 LS \$ - \$ - \$ 50,000.00 \$ 50,000.00	
Utilities Installation/Extension 1 LS \$ 150,000.00 \$ - \$ - \$ - \$ 150,000.00 Engineering Judgment	
Subtotal \$ 1,840,535.31	
GETS Subtotal \$ 2,708,795	
. , , , , ,	
Bid and Scope Contingency 25% \$ 677,199 EPA Guidance	
GETS with Contingency \$ 3,385,994	
Project Management 5% S 169,300 EPA Guidance	
Project management 5% 5 270,880 EPA Guidance 8% \$ 270,880 EPA Guidance	
Construction Management 6% \$ 203,160 EPA Guidance	
or y Logical Condition	
GETS Total \$ 4,029,333	

Five extraction wells at depth of approximately 100 ft bgs.
Two extraction wells at depth of approximately 200 ft bgs.
One extraction well at depth of approximately 500 ft bgs.

	Assembly Description	Qty UOM	Material	Labor	Equipment	Sub Bi	ł	Total Cost	Basis
	33010101 Mobilize/DeMobilize Drilling Rig & Crew	1 LS	\$ -	\$ 16,665.59	\$ 6,659.79	\$ -	ç	23,325.37	
	33020303 Organic Vapor Analyzer Rental, per Day	7 DAY	\$ -	\$ -	\$ -	\$ 37.6	6 \$	263.63	
	33109660 5,000 Gallon Single-wall Steel Aboveground Tank, Includes Cradles, Coating, Fittings, Excludes Foundation, Pumps, Pi	1 EA	\$ 6,743.25	\$ 986.95	\$ -	\$ -	\$	7,730.20	
	33170808 Decontaminate Rig, Augers, Screen (Rental Equipment)	6 DAY	\$ 28.03	666.76	\$ -	\$ -	\$,	
	33220112 Field Technician	66 HR	\$ -	\$	\$ -	\$ -	\$,	
	33230123 6" Stainless Steel, Well Casing	1400 LF	\$ 114.40	\$ 58.87	\$ 57.28	\$ -	\$	322,770.00	
	33230157 2" Pitless Adapter	3 EA	\$ 849.15	\$ 83.72	\$ -	\$ -	\$	2,798.60	
	33230223 6" Stainless Steel, Well Screen	80 LF	\$ 83.40	\$ 6.15	\$ 6.03	\$ -	\$,	
	33230313 6" Stainless Steel, Well Plug	3 EA	\$ 279.00	\$ 15.38	\$ 15.06	\$ -	\$	928.32	
	33230536 4" Submersible Pump, 15-20 GPM, 241'< Head <=300', 1 1/2 hp, w/ controls	3 EA	\$ 1,257.26	\$ 145.34	\$ -	\$ -	\$	4,207.81	
	33231257 Sonic Drilling, 9" OD,Borehole, 100 ft < Depth <= 500 ft	600 LF	\$ -	\$ 59.14	\$ 34.72	\$ -	\$	56,316.00	
	33231124 Mud Drilling, 15" Dia Borehole, Depth <= 100 ft	700 LF	\$ -	\$ 29.19	\$ 48.32	\$ -	\$	54,257.00	
	33231172 Split Spoon Sample, 2" x 24", During Drilling	45 LF	\$ -	\$ -	\$ -	\$ 334.1	1 \$	15,034.95	
	33231182 DOT steel drums, 55 gal., open, 17C	132 EA	\$ 78.83	\$ -	\$ -	\$ -	\$	10,405.85	
	33231186 Well Development Equipment Rental (weekly)	3 WK	\$ -	\$ -	\$ -	\$ 588.3	0 \$	1,764.90	
	33231403 6" Screen, Filter Pack	80 LF	\$ 17.73	\$ 10.66	\$ 8.56	\$ -	\$	2,956.19	
	33232103 6" Well, Bentonite Seal	3 EA	\$ 45.68	\$ 63.79	\$ 51.23	\$ -	\$	482.13	
	33232206 Restricted Area, Well Protection (with 4 Posts & Explosionproof Receptacle)	3 EA	\$ 1,171.42	\$ 973.54	\$ 1.30	\$ -	\$	6,438.79	
	33260211 4" Stainless Steel, Schedule 40, Connection Piping	800 LF	\$ 75.00	\$ 31.32	\$ -	\$ -	\$	85,056.00	
						Subto	tal \$	609,355.11	
	33170904 Load LLW Roll-Off Containers on Truck or directly in disposal pit/landfill	1 EA	\$ -	\$ 160.16	\$ -	\$ -	\$	160.16	
	33170924 Transport LLW Roll-Off Containers (1 per truck)	250 MI	\$ -	\$ -	\$ -	\$ 3.8	5 \$	962.93	
	33190101 Liquid Loading Into 5,000 Gallon Bulk Tank Truck	1 EA	\$ -	\$ 604.82	\$ 337.75	\$ -	\$	942.57	
	33190102 Bulk Solid Waste Loading Into Disposal Vehicle or Bulk Disposal Container	105 BCY	\$ 1.00	\$ 1.39	\$ 0.40	\$ -	5	292.83	
	33190108 Tanker Pumping Equipment to Load Liquid	1 HR	\$ -	\$ -	\$ -	\$ 29.9	3 \$	29.93	
IDW	33190205 Transport Bulk Solid Hazardous Waste, Maximum 20 CY (per Mile)	500 MI	\$ -	\$ -	\$ -	\$ 2.8	9 \$	1,443.00	
management	33190207 Transport Bulk Liquid/Sludge Hazardous Waste, Maximum 5,000 Gallon (per Mile)	250 MI	\$ -	\$ -	\$ -	\$ 2.8	9 \$	721.50	
	33190317 Waste Stream Evaluation Fee, Not Including 50% Rebate on 1st Shipment	5 EA	\$ -	\$ -	\$ -	\$ 69.3	8 \$	346.88	
	33190807 32 Ft. Dump Truck, 6 Mil Liner, disposable	5 EA	\$ 25.73	\$ -	\$ -	\$ -	\$	128.65	
	33190815 Bulk Solid Waste Disposal Container, 20 CY Roll-Off	1 MO	\$ 3,774.00	\$ -	\$ -	\$ -	\$	3,774.00	
	33197270 Landfill Nonhazardous Solid Bulk Waste by CY	103 CY	\$ -	\$ -	\$ -	\$ 25.1	.2 \$	2,587.29	
	33197273 Commercial RCRA landfills, liquid	87 GAL	\$ -	\$ -	\$ -	\$ 0.6	1 \$	53.11	
						Subto	tal \$	11,443	
	Extraction wells Subtotal							620,798	
	LALI BELIOTI WEITS SUDJULGI						ş	020,798	
	Bid and Scope Contingency					10)% \$	62,080	EPA Guidance
	Extraction wells with Contingency						\$	682,878	
	Project Management					4	5% \$	40.072	EPA Guidance
	Construction Management						9% \$ 8% \$		EPA Guidance
						,	,	. 5.,550	
	Extraction wells Total						9	778,481	

GETS O&M costs for both systems include carbon replacements, filter media, spent media disposal, and labor for treatment plant operators, treatment plant sampling, and reporting, Costs for system startup, commissioning, and optimization are also included.

Assembly	Description	Qty	UOM	Material		Labor	Equ	uipment	Sub Bid	Total Cost	Basis
33020402 Decontamination N	Naterials per Sample	48	EA	\$ 14.3	6 \$	-	\$	-	\$ -	\$ 689.3	.8
33021535 Full Size, Portable,	Automated Wastewater Sampler, Daily Rental	8	DAY	\$ -	\$	-	\$	-	\$ 92.13	\$ 737.0	14
33021670 Metals Screen, 25 N	Metals Listed In Method EPA 200.7, Water Analysis	48	EA	\$ -	\$	-	\$	-	\$ 62.00	\$ 2,976.0	10
33021721 Testing, semi-volati	le organics (625, 8270)	48	EA	\$ -	\$	-	\$	-	\$ 105.00	\$ 5,040.0	10
33021720 Testing, purgeable	33021720 Testing, purgeable organics (624, 8260)					-	\$	-	\$ 47.00	\$ 2,820.0	10
33021834 Volatile Organic Co	mpounds (TO-14)	1	EA	\$ -	\$	-	\$	-	\$ 392.98	\$ 392.9	18
33022042 Overnight delivery	service, 21 to 50 lb packages	14	EA	\$ -	\$	-	\$	-	\$ 280.00	\$ 3,920.0	10
33132053 Bulk liquid-phase a	ctivated carbon, Coal-based General Purpose, 8 x 30 Sieve, 900 Iodine, > 10,000 Lb	44578.23	LB	\$ 1.5	3 \$	-	\$	-	\$ -	\$ 68,284.9	3
33132059 Remove Carbon fro	m Vessels, 10,000 - 20,000 Lb Minimum, Transport & Reactivate	37312	LB	\$ 0.4	9 \$	-	\$	-	\$ -	\$ 18,223.3	.8
33132066 Removal, Transport	, Regeneration of Spent Carbon, < 2K to 10 K lb	44578.23	LB	\$ 0.4	9 \$	-	\$	-	\$ -	\$ 21,772.0	1
33190207 Transport Bulk Liqu	id/Sludge Hazardous Waste, Maximum 5,000 Gallon (per Mile)	800	MI	\$ -	\$	-	\$	-	\$ 2.89	\$ 2,308.8	0
33190232 Van Trailer Transpo	rtation Hazardous Waste 400 - 499 Miles	800	MI	\$ -	\$	-	\$	-	\$ 3.00	\$ 2,397.6	0
33190311 Commercial RCRA I	andfills, truck washout	1	EA	\$ -	\$	-	\$	-	\$ 2,005.72	\$ 2,005.7	2
33197275 Landfill Hazard Liqu	id Bulk Waste Requiring Stabilization	4204.8	GAL	\$ -	\$	-	\$	-	\$ 1.94	\$ 8,167.8	2
33220102 Project Manager		120	HR	\$ -	\$	125.62	\$	-	\$ -	\$ 15,074.4	4
33220106 Staff Engineer		60	HR	\$ -	\$	104.61	\$	-	\$ -	\$ 6,276.8	66
33220109 Staff Scientist		60	HR	\$ -	\$	80.44	\$	-	\$ -	\$ 4,826.4	10
33220110 QA/QC Officer		40	HR	\$ -	\$	69.86	\$	-	\$ -	\$ 2,794.5	8
33220114 Word Processing/C	erical	80	HR	\$ -	\$	57.71	\$	-	\$ -	\$ 4,616.9	7
33220115 Draftsman/CADD		40	HR	\$ -	\$	60.44	\$	-	\$ -	\$ 2,417.6	2
33240101 Other Direct Costs		1	LS	\$ -	\$	2,478.00	\$	-	\$ -	\$ 2,478.0	10
33240104 Startup Costs		1	LS	\$ 58,283.0	0 \$	35,253.04	##		\$ -	\$ 105,960.5	4
33420405 Water/Sewer Utility	y Charge	780	MGL	\$ 6.4	0 \$	-	\$	-	\$ -	\$ 4,992.0	10
33420101 Electrical Charge		264000	KWH	\$ 0.1	2 \$	-	\$	-	\$ -	\$ 32,234.4	10
									Subtotal	\$ 321,407.0	8
O&M First year Subtotal										\$ 642,83	4
Bid and Scope Contingency									10%	\$ 64,28	1 EPA Guidance
O&M First year with Contingend	y									\$ 707,09	16
Project Management									5%	\$ 35,3	5 EPA Guidance
O&M First year Total										\$ 742,45	0

GETS O&M costs for both systems include carbon replacements, filter media, spent media disposal, and labor for treatment plant operators, treatment plant sampling, and reporting,

Assembly	Description	Qty	UOM	Material	Labor	Equ	ipment	Sub Bid	To	tal Cost	Basis
33020402 Decontamination Ma	terials per Sample	48	EA	\$ 14.36	\$ -	\$	-	\$ -	\$	689.18	
33021535 Full Size, Portable, Au	tomated Wastewater Sampler, Daily Rental	8	DAY	\$ -	\$ -	\$	-	\$ 92.13	\$	737.04	
33021670 Metals Screen, 25 Me	etals Listed In Method EPA 200.7, Water Analysis	48	EA :	\$ -	\$ -	\$	-	\$ 62.00	\$	2,976.00	
33021721 Testing, semi-volatile	organics (625, 8270)	48	EA :	\$ -	\$ -	\$	-	\$ 105.00	\$	5,040.00	
33021720 Testing, purgeable or	ganics (624, 8260)	60	EA	\$ -	\$ -	\$	-	\$ 47.00	\$	2,820.00	
33021834 Volatile Organic Com	pounds (TO-14)	1	EA	\$ -	\$ -	\$	-	\$ 392.98	\$	392.98	
33022042 Overnight delivery se	rvice, 21 to 50 lb packages	14	EA	\$ -	\$ -	\$	-	\$ 280.00	\$	3,920.00	
33132053 Bulk liquid-phase act	vated carbon, Coal-based General Purpose, 8 x 30 Sieve, 900 Iodine, > 10,000 Lb	44578.23	LB :	\$ 1.53	\$ -	\$	-	\$ -	\$	68,284.93	
33132059 Remove Carbon from	Vessels, 10,000 - 20,000 Lb Minimum, Transport & Reactivate	37312	LB :	\$ 0.49	\$ -	\$	-	\$ -	\$	18,223.18	
33132066 Removal, Transport,	Regeneration of Spent Carbon, < 2K to 10 K lb	44578.23	LB	\$ 0.49	\$ -	\$	-	\$ -	\$	21,772.01	
33190207 Transport Bulk Liquid	/Sludge Hazardous Waste, Maximum 5,000 Gallon (per Mile)	800	MI	\$ -	\$ -	\$	-	\$ 2.89	\$	2,308.80	
33190232 Van Trailer Transport	ation Hazardous Waste 400 - 499 Miles	800	MI	\$ -	\$ -	\$	-	\$ 3.00	\$	2,397.60	
33190311 Commercial RCRA lar	dfills, truck washout	1	EA	\$ -	\$ -	\$	-	\$ 2,005.72	\$	2,005.72	
33197275 Landfill Hazard Liquid	Bulk Waste Requiring Stabilization	4204.8	GAL	\$ -	\$ -	\$	-	\$ 1.94	\$	8,167.82	
33220102 Project Manager		120	HR	\$ -	\$ 125.62	\$	-	\$ -	\$	15,074.44	
33220106 Staff Engineer		60	HR	\$ -	\$ 104.61	\$	-	\$ -	\$	6,276.86	
33220109 Staff Scientist		60	HR	\$ -	\$ 80.44	\$	-	\$ -	\$	4,826.40	
33220110 QA/QC Officer		40	HR	\$ -	\$ 69.86	\$	-	\$ -	\$	2,794.58	
33220114 Word Processing/Cle	rical	80	HR	\$ -	\$ 57.71	\$	-	\$ -	\$	4,616.97	
33220115 Draftsman/CADD		40	HR	\$ -	\$ 60.44	\$	-	\$ -	\$	2,417.62	
33240101 Other Direct Costs		1	LS	\$ -	\$ 2,478.00	\$	-	\$ -	\$	2,478.00	
33420405 Water/Sewer Utility	Charge	780	MGL	\$ 6.40	\$ -	\$	-	\$ -	\$	4,992.00	
33420101 Electrical Charge		264000	KWH	\$ 0.12	\$ -	\$	-	\$ -	\$	32,234.40	
								Subtotal	\$ 2	15,446.54	
O&M Subtotal									\$	215,447	
Bid and Scope Contingency								10%	\$	21,545	EPA Guidance
O&M with Contingency									\$	236,991	
Project Management								5%	\$	11,850	EPA Guidance
O&M Total									\$	248,841	

Description:	12	monitoring wells will be in	nstalled. Well development time is included.
	8	wells to a depth of	100 ft
	2	wells to a depth of	200 ft
	2	wells to a depth of	500 ft
	Well installation and development (days) =	27	
	Mobe/Demobe (days) =	2	
	Adverse weather/no dig time (days) =	6	
	Total Working Days =	35	
	Total Travel Days =	49	
	Installation Duration (weeks) =	7	

Description	Qty	UOM	Unit Cost	Total	Notes
Mobilization/Demobilization	1	LS	\$1,500	\$1,500	Professional Judgment
Health and Safety Submission	1	LS	\$500	\$500	Professional Judgment
Geologist	35	days	\$800	\$28,000	DOL May 2016 data
Per diem (Geologist)	49	days	\$192	\$9,408	GSA 2018 rates
Decontamination Pad	1	LS	\$500	\$500	Vendor Quote
Drilling Rig	35	days	\$3,000	\$105,000	Vendor Quote
Per Diem (Drilling Crew,2)	49	days	\$384	\$18,816	GSA 2018 rates
55-Gallon Drums	24	each	\$75	\$1,800	Vendor Quote
Well completion	12	LS	\$500	\$6,000	Vendor Quote
Rental Truck	7	weeks	\$350	\$2,450	Online Quote, includes fuel
Misc ODC	35	per day	\$100	\$3,500	Professional Judgment
IDW handling	24	per well	\$75	\$1,800	Vendor Quote, Pilot Study
2-man survey crew	12	per well	\$150	\$1,800	Vendor Quote
Tubing	17	per 100 LF	\$125.00	\$2,128	Vendor Quote
Subtotal				\$183,202	_
Bid and Scope Contingency			10%	\$18,320	EPA Guidance
Well Installation with Contingency				\$201,522	
Project Management			5%	\$10,076	EPA Guidance
Well Installation Total				\$211,598	

Description: 45 monitoring wells will be sampled. Taking into account the QC samples, a total of Samples will be analyzed for VOC, metals, and 1,4-dioxane.

60 samples will be collected per event

Wells sampled per day =

One report per year.

Quarterly sampling for first year, semi-annual for the next 3 years followed by annual sampling of

30 wells, including QC samples.

Description	Qty	UOM	Unit Cost	Total	Notes
Groundwater Sampling Event (First yea	<u>r)</u>				
Disposable Materials per Sample	240	EA	\$25	\$6,000	Site Experience
PID Meter	6	weeks	\$300	\$1,800	Vendor Online Catalogue
Water level meter	6	weeks	\$80	\$480	Vendor Online Catalogue
Multimeter (including turbidity)	6	weeks	\$400	\$2,400	Vendor Online Catalogue
Pump	6	weeks	\$350	\$2,100	Vendor Online Catalogue
Misc ODC	32	per day	\$20	\$640	Professional Judgment
Rental truck for sample collection	6	weeks	\$400	\$2,400	Online Quote, includes fuel
Testing, VOC	240	EA	\$47	\$11,280	Site Experience
Testing, 1,4-dioxane	240	EA	\$90	\$21,600	Site Experience
Testing, metals	240	EA	\$62	\$14,880	Site Experience
Data Validation	240	EA	\$33	\$7,920	Site Experience
Field Crew (2-person)	32	days	\$1,600	\$51,200	Site Experience
Per Diem (Sampling Crew,2)	32	days	\$384	\$12,288	GSA 2018 rates
Subtotal				\$134,988	
Bid and Scope Contingency			10%	\$13,499	EPA Guidance
First Year Sampling with Contingency				\$148,487	
Project Management			5%	\$7,424	EPA Guidance
First Year Sampling Total				\$155,911	

Groundwater Sampling Event (Baseline Event)

Years 2-4 Sampling Total				\$77,956	
Project Management			5%	\$3,712	EPA Guidance
Years 2-3 Sampling with Contingency				\$74,243	
Bid and Scope Contingency			10%	\$6,749	EPA Guidance
Subtotal				\$67,494	
Per Diem (Sampling Crew,2)	16	days	\$384	\$6,144	GSA 2018 rates
Field Crew (2-person)	16	days	\$1,600	\$25,600	Site Experience
Data Validation	120	EA	\$33	\$3,960	Site Experience
Testing, metals	120	EA	\$62	\$7,440	Site Experience
Testing, 1,4-dioxane	120	EA	\$90	\$10,800	Site Experience
Testing, VOC	120	EA	\$47	\$5,640	Site Experience
Rental truck for sample collection	3	weeks	\$400	\$1,200	Online Quote, includes fuel
Misc ODC	16	per day	\$20	\$320	Professional Judgment
Pump		weeks	\$350	\$1,050	Vendor Online Catalogue
Multimeter (including turbidity)	3	weeks	\$400	\$1,200	Vendor Online Catalogue
Water level meter	3	weeks	\$80	\$240	Vendor Online Catalogue
PID Meter	3	weeks	\$300	\$900	Vendor Online Catalogue
Disposable Materials per Sample	120	EA	\$25	\$3,000	Site Experience
Groundwater Sampling Event (Years 2-4)					
Baseline Sampling Total				\$38,978	
Project Management			5%	\$1,856	EPA Guidance
Baseline Sampling with Contingency				\$37,122	
Bid and Scope Contingency			10%	\$3,375	EPA Guidance
Subtotal	Ũ	44,5	 '	\$33,747	557. 2525 7525
Per Diem (Sampling Crew,2)	8	days	\$384	\$3,072	GSA 2018 rates
Field Crew (2-person)	8	days	\$1,600	\$12,800	Site Experience
Data Validation	60	EA	\$33	\$1,980	Site Experience
Testing, metals	60	EA	\$62	\$3,720	Site Experience
Testing, 1,4-dioxane	60	EA	\$90	\$5,400	Site Experience
Testing, VOC	60	EA	\$47	\$2,820	Site Experience
Rental truck for sample collection	1.5	weeks	\$400	\$600	Online Quote, includes fuel
Misc ODC	8	per day	\$20	\$160	Professional Judgment
Pump	1.5	weeks	\$350	\$525	Vendor Online Catalogue
Multimeter (including turbidity)	1.5	weeks	\$400	\$600	Vendor Online Catalogue
Water level meter	1.5	weeks	\$80	\$120	Vendor Online Catalogue
PID Meter	1.5	weeks	\$300	\$450	Vendor Online Catalogue
		1.5	1.5 weeks	1.5 weeks \$300	1.5 weeks \$300 \$450

Groundwater Sampling Event (Years 5-30)

Disposable Materials per Sample	30	EA	\$25	\$750	Site Experience
PID Meter	1	weeks	\$300	\$300	Vendor Online Catalogue
Water level meter	1	weeks	\$80	\$80	Vendor Online Catalogue
Multimeter (including turbidity)	1	weeks	\$400	\$400	Vendor Online Catalogue
Pump	1	weeks	\$350	\$350	Vendor Online Catalogue
Misc ODC	8	per day	\$20	\$160	Professional Judgment
Rental truck for sample collection	1	weeks	\$400	\$400	Online Quote, includes fuel
Testing, VOC	30	EA	\$47	\$1,410	Site Experience
Testing, 1,4-dioxane	30	EA	\$90	\$2,700	Site Experience
Testing, metals	30	EA	\$62	\$1,860	Site Experience
Data Validation	30	EA	\$33	\$990	Site Experience
Field Crew (2-person)	4	days	\$1,600	\$6,400	Site Experience
Per Diem (Sampling Crew,2)	4	days	\$384	\$1,536	GSA 2018 rates
Subtotal				\$17,336	
Bid and Scope Contingency			10%	\$1,734	EPA Guidance
Years 5-30 Sampling with Contingency				\$19,070	
Project Management			5%	\$953	EPA Guidance
Years 5-30 Sampling Total				\$20,023	
				\$20,023	
Years 5-30 Sampling Total Groundwater Monitoring Report (Annual)				\$20,023	
Groundwater Monitoring Report (Annual) Project Manager	40	HR	\$126	\$5,025	
Groundwater Monitoring Report (Annual) Project Manager Staff Engineer	60	HR	\$105	\$5,025 \$6,277	
Groundwater Monitoring Report (Annual) Project Manager Staff Engineer Staff Scientist	60 120	HR HR	\$105 \$80	\$5,025 \$6,277 \$9,653	
Groundwater Monitoring Report (Annual) Project Manager Staff Engineer Staff Scientist QA/QC Officer	60 120 40	HR HR HR	\$105 \$80 \$70	\$5,025 \$6,277 \$9,653 \$2,795	
Groundwater Monitoring Report (Annual) Project Manager Staff Engineer Staff Scientist	60 120	HR HR	\$105 \$80 \$70 \$58	\$5,025 \$6,277 \$9,653	
Groundwater Monitoring Report (Annual) Project Manager Staff Engineer Staff Scientist QA/QC Officer	60 120 40	HR HR HR	\$105 \$80 \$70 \$58 \$60	\$5,025 \$6,277 \$9,653 \$2,795 \$2,308 \$2,418	
Groundwater Monitoring Report (Annual) Project Manager Staff Engineer Staff Scientist QA/QC Officer Word Processing/Clerical	60 120 40 40	HR HR HR HR	\$105 \$80 \$70 \$58	\$5,025 \$6,277 \$9,653 \$2,795 \$2,308	
Groundwater Monitoring Report (Annual) Project Manager Staff Engineer Staff Scientist QA/QC Officer Word Processing/Clerical Draftsman/CADD	60 120 40 40 40	HR HR HR HR	\$105 \$80 \$70 \$58 \$60	\$5,025 \$6,277 \$9,653 \$2,795 \$2,308 \$2,418	
Groundwater Monitoring Report (Annual) Project Manager Staff Engineer Staff Scientist QA/QC Officer Word Processing/Clerical Draftsman/CADD Other Direct Costs	60 120 40 40 40	HR HR HR HR	\$105 \$80 \$70 \$58 \$60	\$5,025 \$6,277 \$9,653 \$2,795 \$2,308 \$2,418 \$100	EPA Guidance
Groundwater Monitoring Report (Annual) Project Manager Staff Engineer Staff Scientist QA/QC Officer Word Processing/Clerical Draftsman/CADD Other Direct Costs Subtotal	60 120 40 40 40	HR HR HR HR	\$105 \$80 \$70 \$58 \$60 \$100	\$5,025 \$6,277 \$9,653 \$2,795 \$2,308 \$2,418 \$100 \$28,575	EPA Guidance
Groundwater Monitoring Report (Annual) Project Manager Staff Engineer Staff Scientist QA/QC Officer Word Processing/Clerical Draftsman/CADD Other Direct Costs Subtotal Bid and Scope Contingency	60 120 40 40 40	HR HR HR HR	\$105 \$80 \$70 \$58 \$60 \$100	\$5,025 \$6,277 \$9,653 \$2,795 \$2,308 \$2,418 \$100 \$28,575	

Description: Tasks included are: document review, site inspection, travel, and reporting.

FYRs would be required until the cleanup goals for the Site are achieved

Assume quarterly LUC inspections require 1 person for 1/2 day plus reporting

Description	Qty	UOM	Unit Cost	Total	Notes
Five-Year Review + LI	IC inspections				
Project Manager	40	HR	\$126	\$5,025	
Staff Engineer	60	HR	\$105	\$6,277	
Staff Scientist	80	HR	\$80	\$6,435	
QA/QC Officer	40	HR	\$70	\$2,795	
Word Processing/Clerical	40	HR	\$58	\$2,308	
Draftsman/CADD	40	HR	\$60	\$2,418	
Junior Scientist	80	HR	\$60	\$4,835	
Rental vehicle for LUC inspections	s 80	day	\$75	\$6,000	
Other Direct Costs	1	LS	\$100	\$100	
Subtotal				\$36,193	
Bid and Scope Contingency			10%	\$3,619 EPA Gu	idance
Monitoring Report with Continge	ency			\$39,812	
Project Management			5%	\$1,991 EPA Gu	idance
Monitoring Report Total				\$41,803	

Description:

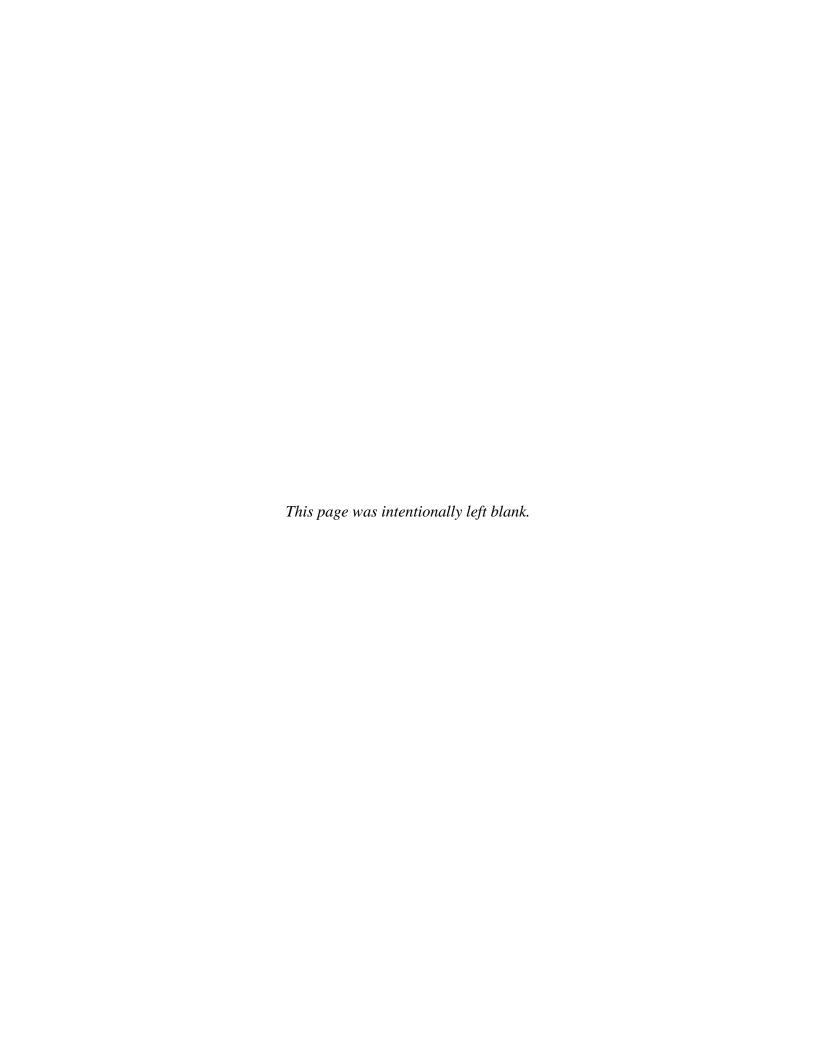
Assumes a Mid Level Engineer/Scientist would be at the site for the entire construction of the systems.

The project manager would be onsite one day per week

The concstruction of both systems, including startup time =

52 weeks.

	Description	Qty	UOM	Unit Cost	Total		Notes
	Project Manager Mid Level Engineer	520 2860	hour hour	\$175 \$146	\$91,000 \$417,560	Professional Judgment Professional Judgment	
Oversight Personnel	Mid Level Scientist	2860	hour	\$130	\$371,800	Professional Judgment	
	Rental Truck	104	weeks	\$350	\$36,400	Online pricing, includes fuel	
	Per diem	728	days	\$384	\$279,552	GSA 2018 rates	
				Sub	ototal \$1,196,312		



Assume a zone of

50 ft will be injected in each area.

Assume a radius of influence of

30 ft. To account for overlap, a 20% increase to the number of points is assumed.

Assume natural oxidant demand (NOD) =

7 g NaMnO4/kg soil.

Sodium permanganate is shipped as a

40% by weight solution. Each truckload has

42,000 lbs of 40% by weight NaMnO4.

Area ID	Source Area Footprint (sq. ft.)	Depth Interval	(ft bgs)	Targeted zone length (ft)	Number of Injection Points	Treatment Volume (ft3)	Sodium Permanganate for NOD (lbs)	Concentration weight - 40% NaMnO4 by weight (lb)	Truckloads of 40% NaMnO4
Teleflex	444,000	100			189	22,200,000	161,791	404,478	10
Ford	150,000	200			64	15,000,000	109,318	273,296	7
Facility	130,000	500		50	04				,
Spra Fin	278,000	100			119	13,900,000	101,302	253,254	6
Spra Fin 2	32,000	200			14	1,600,000	11,661	29,152	1
	Total				386	52,700,000	384,072	960,179	23

Description:	Assume 3 rigs working simultaneously to drill injection points with two technicians in each rig.							
	Assume	2 platforms with 2 tech	nicians will inject	simultaneously to	0	8 injection points.		
	Target area (sq.ft) =		444,000					
	Average drilling depth =		100					
	Radius of Influence (ft)=			30				
	Number of injection points	(+overlap) =		189				
	Assume drilling rate (LF/ho		50					
	Assume time for completion			0.25				
	Adverse weather/ no dig da			0.5				
	Drilling time (days) =			16				
	Injection time (days) =			12				
	Mobe/Demobe (days) =			2				
	Completion time (days) =			2				
	Adverse weather/no dig tir	ne (days) =		7				

39

55 8

Total Working Days =

Treatment Duration (weeks) =

Total Travel Days =

	Description	Qty	UOM	Unit Cost	Total	Notes
	Mobilization/Demobilization	1	LS	\$3,500	\$3,500	Professional Judgment, Pilot Study
	Health and Safety Submission	1	LS	\$1,500	\$1,500	Professional Judgment, Pilot Study
Drilling and	Borehole Drilling (6")	18,900	per ft	\$62	\$1,171,800	Vendor Quote
Injection Services	Borehole Completion	189	per well	\$250	\$47,250	Vendor Quote
injection services	Decontamination Pad	5	LS	\$500	\$2,500	Professional Judgment
	Injection Platforms	12	days	\$5,000	\$60,000	Includes injection platforms and other direct costs
1	Misc ODC	39	days	\$100	\$3,900	Professional Judgment
	Decontamination	189	per well	\$100	\$18,900	Vendor Quote, Pilot Study
	Delivery/Pickup of 20 cubic yard roll-offs	27	each	\$700	\$19,233	Vendor Quote
	Rental of 20 cubic yard roll off	8	per week	\$300	\$2,400	Vendor Quote
IDW Handling	Transportation and disposal of IDW roll-offs (assumes non-hazardous)	27	each	\$850	\$23,354	Vendor Quote
	Delivery/Pickup of 21,000 gallon fraq tank	1	each	\$1,000	\$1,000	Vendor Quote
	Rental of 21,000 gallon fraq tank	55	per day	\$35	\$1,925	Vendor Quote
	Transportation and disposal of IDW liquid (non-hazardous)	21,000	per gallon	\$0.25	\$5,250	Vendor Quote
	Water truck, off highway, 6000 gal (2)	2	month	\$29,418	\$58,836	2016 RSMeans, 01 54 33 6950, includes water cost
Amendment	Sodium permanganate	404,478	per lb	\$1.65	\$667,388	Vendor Quote
Injections	Trucks of 40% sodium permanganate	10	per load	\$4,400	\$42,374	Vendor Quote
	Sales tax		percent	6.0%	\$42,586	
	Subtotal				\$2,173,695	
	Bid and Scope Contingency			20%	\$434,739	EPA Guidance
	Teleflex with Contingency				\$2,608,434	
	Project Management			6%	\$156,506	EPA Guidance
	Teleflex Total				\$2,764,940	

Description: Assume 50% of injection points will be used in the second round of injections Assume 2 platforms with 2 technicians will inject simultaneously to

14

2

444,000 Target area (sq.ft) = Average drilling depth = 100 Radius of Influence (ft)= 30 95 Number of injection points (+overlap) = Injection time (days) = 6 Mobe/Demobe (days) = 2 Adverse weather/no dig time (days) = 2 Total Working Days = 10

Total Travel Days =

Treatment Duration (weeks) =

8 injection points.

	Description	Qty	иом	Unit Cost	Total	Notes
	Mobilization/Demobilization	1	LS	\$1,500	\$1,500	Professional Judgment, Pilot Study
	Health and Safety Submission	1	LS	\$500	\$500	Professional Judgment, Pilot Study
Injection Services	Decontamination Pad	2	LS	\$500	\$1,000	Professional Judgment
	Injection Platforms	10	days	\$5,000	\$50,000	Includes injection platforms and other direct costs
	Misc ODC	10	days	\$100	\$1,000	Professional Judgment
	Decontamination	95	per well	\$100	\$9,500	Vendor Quote, Pilot Study
IDW Handline	Delivery/Pickup of 20 cubic yard roll-offs (2)	2	each	\$700	\$1,400	Vendor Quote
IDW Handling	Rental of 20 cubic yard roll off	2	per week	\$300	\$600	Vendor Quote
	Transportation and disposal of IDW roll-offs (assumes non-hazardous)	2	each	\$850	\$1,700	Vendor Quote
	Water truck, off highway, 6000 gal (2)	0.5	month	\$29,418	\$14,709	2016 RSMeans, 01 54 33 6950, includes water cost
Amendment	Sodium permanganate	202,239	per lb	\$1.20	\$242,687	Vendor Quote, Pilot Study
Injections	Trucks of 40% sodium permanganate	5	per gallon	\$80	\$385	Vendor Quote, Pilot Study
	Sales tax		percent	6.0%	\$14,584	
	Subtotal				\$339,565	
	Bid and Scope Contingency			20%	\$67,913	EPA Guidance
	Teleflex with Contingency				\$407,478	
	Project Management			8%	\$32,598	EPA Guidance
	Teleflex Total				\$440,076	

Description: Assume 25% of injection points will be used in the second round of injections
Assume 2 platforms with 2 technicians will inject simultaneously to

Target area (sq.ft) = 444,000 Average drilling depth = 100

Radius of Influence (ft)= 30 48 Number of injection points (+overlap) = Injection time (days) = 3 Mobe/Demobe (days) = 2 Adverse weather/no dig time (days) = 1 Total Working Days = 6 Total Travel Days = 9 Treatment Duration (weeks) = 2 8 injection points.

	Description	Qty	иом	Unit Cost	Total	Notes
	Mobilization/Demobilization	1	LS	\$1,500	\$1,500	Professional Judgment, Pilot Study
	Health and Safety Submission	1	LS	\$500	\$500	Professional Judgment, Pilot Study
Injection Services	Decontamination Pad	2	LS	\$500	\$1,000	Professional Judgment
	Injection Platforms	6	days	\$5,000	\$30,000	Includes injection platforms and other direct costs
	Misc ODC	6	days	\$100	\$600	Professional Judgment
	Decontamination	48	per well	\$100	\$4,800	Vendor Quote, Pilot Study
	Delivery/Pickup of 20 cubic yard roll-offs (2)	2	each	\$700	\$1,400	Vendor Quote
IDW Handling	Rental of 20 cubic yard roll off	2	per week	\$300	\$600	Vendor Quote
	Transportation and disposal of IDW roll-offs (assumes non-hazardous)	2	each	\$850	\$1,700	Vendor Quote
	Water truck, off highway, 6000 gal (2)	0.5	month	\$29,418	\$14,709	2016 RSMeans, 01 54 33 6950, includes water cost
Amendment	Sodium permanganate	101,119	per lb	\$1.20	\$121,343	Vendor Quote, Pilot Study
Injections	Trucks of 40% sodium permanganate	2	per gallon	\$80	\$193	Vendor Quote, Pilot Study
	Sales tax		percent	6.0%	\$7,292	
	Subtotal				\$185,637	
	Bid and Scope Contingency			20%	\$37,127	EPA Guidance
	Teleflex with Contingency				\$222,764	
	Project Management			8%	\$17,821	EPA Guidance
	Teleflex Total				\$240,586	

Description: Assume 3 rigs working simultaneously to drill injection points with two technicians in each rig.

Assume 2 platforms with 2 technicians will inject simultaneously to 5 injection points.

Assume 2 platforms with 2 to	connections with inject simultaneously to		
Target area (sq.ft) =	150,000		
Average drilling depth =	350		
Radius of Influence (ft)=	30		
Number of injection points (+overlap) =	64		
Assume drilling rate (LF/hour) =	50		
Assume time for completion of point (hr/point) =		0.25	
Adverse weather/ no dig day (days per week) =		0.5	
Drilling time (days) =	19		
Injection time (days) =	7		
Mobe/Demobe (days) =	2		
Completion time (days) =	1		
Adverse weather/no dig time (days) =	6		
Total Working Days =	35		
Total Travel Days =	49		
Treatment Duration (weeks) =	7		

	Description	Qty	иом	Unit Cost	Total	Notes
	Mobilization/Demobilization	1	LS	\$3,500	\$3,500	Professional Judgment, Pilot Study
	Health and Safety Submission	1	LS	\$1,500	\$1,500	Professional Judgment, Pilot Study
	Borehole Drilling (6")	22,400	per ft	\$62	\$1,388,800	Vendor Quote
Drilling and	Borehole Completion	64	per well	\$250	\$1,368,860	Vendor Quote
Injection Services	Decontamination Pad	5	LS	\$500	\$2,500	Professional Judgment
	Injection Platforms	5 7	days	\$5,000	\$35,000	Includes injection platforms and other direct costs
	Misc ODC	35	days	\$100	\$3,500	Professional Judgment
	MISCODC	35	uays	\$100	\$3,500	Professional Judgment
	Decontamination	64	per well	\$100	\$6,400	Vendor Quote, Pilot Study
	Delivery/Pickup of 20 cubic yard roll-offs	33	each	\$700	\$23,100	Vendor Quote
	Rental of 20 cubic yard roll off	7	per week	\$300	\$2,100	Vendor Quote
IDW Handling	Transportation and disposal of IDW roll-offs (assumes non-hazardous)	33	each	\$850	\$28,050	Vendor Quote
15 TT TTGTTGTT	Delivery/Pickup of 21,000 gallon frag tank	1	each	\$1,000	\$1,000	Vendor Quote
	Rental of 21,000 gallon frag tank	49	per day	\$35	\$1,715	Vendor Quote
	Transportation and disposal of IDW liquid (non-hazardous)	21,000	per gallon	\$0.25	\$5,250	Vendor Quote
	Transportation and disposal of 15 W Inquia (Non Hazardous)	21,000	per ganon	J 0.23	\$3,230	vendor quote
	Water truck, off highway, 6000 gal (2)	1.75	month	\$29,418	\$51,482	2016 RSMeans, 01 54 33 6950
Amendment	Sodium permanganate	273,296	per lb	\$1.20	\$327,955	Vendor Quote, Pilot Study
Injections	Trucks of 40% sodium permanganate	7	per gallon	\$80	\$521	Vendor Quote, Pilot Study
	Sales tax		percent	6.0%	\$19,709	
	Subtotal				\$1,918,080	
	Bid and Scope Contingency			20%	\$383,616	EPA Guidance
	Ford Facility with Contingency				\$2,301,697	
	Project Management			5%	\$115,085	EPA Guidance
				5,0	. ,	
	Ford Facility Total				\$2,416,781	

Description: 50% of injection points will be used in the second round of injections Assume Assume 2 platforms with 2 technicians will inject simultaneously to Target area (sq.ft) = 150,000 Average drilling depth = 350 30 Radius of Influence (ft)= 32 Number of injection points (+overlap) = 0.5 Adverse weather/ no dig day (days per week) = 4 Injection time (days) = Mobe/Demobe (days) = 2 Adverse weather/no dig time (days) = 2 Total Working Days = 8 12 Total Travel Days = Treatment Duration (weeks) = 2

	Description	Qty	UOM	Unit Cost	Total	Notes
	Mobilization/Demobilization	1	LS	\$1,500	\$1,500	Professional Judgment, Pilot Study
	Health and Safety Submission	1	LS	\$500	\$500	Professional Judgment, Pilot Study
Injection Services	Decontamination Pad	2	LS	\$500	\$1,000	Professional Judgment
	Injection Platforms	4	days	\$5,000	\$20,000	Includes injection platforms and other direct costs
	Misc ODC	8	days	\$100	\$800	Professional Judgment
	Decontamination	32	per well	\$100	\$3,200	Vendor Quote, Pilot Study
IDM/ Haradiina	Delivery/Pickup of 20 cubic yard roll-offs	2	each	\$700	\$1,400	Vendor Quote
IDW Handling	Rental of 20 cubic yard roll off	2	per week	\$300	\$600	Vendor Quote
	Transportation and disposal of IDW roll-offs (assumes non-hazardous)	2	each	\$850	\$1,700	Vendor Quote
	Water truck, off highway, 6000 gal (2)	0.5	month	\$29,418	\$14,709	2016 RSMeans, 01 54 33 6950
Amendment	Sodium permanganate	136,648	per lb	\$1.20	\$163,977	Vendor Quote, Pilot Study
Injections	Trucks of 40% sodium permanganate	3	per gallon	\$80	\$260	Vendor Quote, Pilot Study
	Sales tax		percent	6.0%	\$9,854	
	Subtotal				\$219,501	
	Bid and Scope Contingency			20%	\$43,900	EPA Guidance
	Ford Facility with Contingency				\$263,401	
	Project Management			8%	\$21,072	EPA Guidance
	Ford Facility Total				\$284,473	

Description: 25% of injection points will be used in the second round of injections Assume Assume 2 platforms with 2 technicians will inject simultaneously to Target area (sq.ft) = 150,000 Average drilling depth = 350 30 Radius of Influence (ft)= 16 Number of injection points (+overlap) = 0.5 Adverse weather/ no dig day (days per week) = 2 Injection time (days) = Mobe/Demobe (days) = 2 Adverse weather/no dig time (days) = Total Working Days = 5 Total Travel Days = 7 Treatment Duration (weeks) =

	Description	Qty	UOM	Unit Cost	Total	Notes
	Mobilization/Demobilization	1	LS	\$1,500	\$1,500	Professional Judgment, Pilot Study
	Health and Safety Submission	1	LS	\$500	\$500	Professional Judgment, Pilot Study
Injection Services	Decontamination Pad	2	LS	\$500	\$1,000	Professional Judgment
	Injection Platforms	2	days	\$5,000	\$10,000	Includes injection platforms and other direct costs
	Misc ODC	5	days	\$100	\$500	Professional Judgment
	Decontamination	16	per well	\$100	\$1,600	Vendor Quote, Pilot Study
IDM/ Haradiina	Delivery/Pickup of 20 cubic yard roll-offs	2	each	\$700	\$1,400	Vendor Quote
IDW Handling	Rental of 20 cubic yard roll off	1	per week	\$300	\$300	Vendor Quote
	Transportation and disposal of IDW roll-offs (assumes non-hazardous)	2	each	\$850	\$1,700	Vendor Quote
	Water truck, off highway, 6000 gal (2)	0.25	month	\$29,418	\$7,355	2016 RSMeans, 01 54 33 6950
Amendment	Sodium permanganate	68,324	per lb	\$1.20	\$81,989	Vendor Quote, Pilot Study
Injections	Trucks of 40% sodium permanganate	2	per gallon	\$80	\$130	Vendor Quote, Pilot Study
	Sales tax		percent	6.0%	\$4,927	
•	Subtotal				\$112,900	
	Bid and Scope Contingency			20%	\$22,580	EPA Guidance
	Ford Facility with Contingency				\$135,481	
	Project Management			8%	\$10,838	EPA Guidance
	Ford Facility Total				\$146,319	

Description: 3 rigs working simultaneously for EOS injections with two technicians in each rig. Assume Assume 2 platforms with 2 technicians will inject simultaneously to 278,000 Target area (sq.ft) = 32,000 Average drilling depth = 100 200 30 Radius of Influence (ft)= 119 Number of injection points (+overlap) = 14 Assume drilling rate (LF/hour) = 50 Assume time for completion of point (hr/point) = 0.25 Adverse weather/ no dig day (days per week) = 0.5 Drilling time (days) = 13 Injection time (days) = 9 Mobe/Demobe (days) = 2 Completion time (days) = 2 Adverse weather/no dig time (days) = Total Working Days = 32 Total Travel Days = 45

7

Treatment Duration (weeks) =

	Description	Qty	иом	Unit Cost	Total	Notes
	Mobilization/Demobilization	1	LS	\$3,500	\$3,500	Professional Judgment, Pilot Study
	Health and Safety Submission	1	LS	\$1,500	\$1,500	Professional Judgment, Pilot Study
Dailling	Borehole Drilling (6")	14700	per ft	\$62	\$911,400	Vendor Quote
Drilling and Injection Services	Borehole Completion	133	per well	\$250	\$33,250	Vendor Quote
injection services	Decontamination Pad	5	LS	\$500	\$2,500	Professional Judgment
	Injection Platforms	9	days	\$5,000	\$45,000	Includes injection platforms and other direct costs
	Misc ODC	32	days	\$100	\$3,200	Professional Judgment
	Decontamination	133	per well	\$100	\$13,300	Vendor Quote, Pilot Study
	Delivery/Pickup of 20 cubic yard roll-offs	22	each	\$700	\$15,400	Vendor Quote
	Rental of 20 cubic yard roll off	7	per week	\$300	\$2,100	Vendor Quote
IDW Handling	Transportation and disposal of IDW roll-offs (assumes non-hazardous)	22	each	\$850	\$18,700	Vendor Quote
_	Delivery/Pickup of 21,000 gallon frag tank	1	each	\$1,000	\$1,000	Vendor Quote
	Rental of 21,000 gallon fraq tank	45	per day	\$35	\$1,575	Vendor Quote
	Transportation and disposal of IDW liquid (non-hazardous)	21,000	per gallon	\$0.25	\$5,250	Vendor Quote
	Water truck, off highway, 6000 gal (2)	1.75	month	\$29,418	\$51,482	2016 RSMeans, 01 54 33 6950
Amendment	Sodium permanganate	282,406	per lb	\$1.20	\$338,887	Vendor Quote, Pilot Study
Injections	Trucks of 40% sodium permanganate	7	per gallon	\$80	\$538	Vendor Quote, Pilot Study
	Sales tax		percent	6.0%	\$20,365	
	Subtotal				\$1,468,947	
	Bid and Scope Contingency			10%	\$146,895	EPA Guidance
	Spra Fin with Contingency				\$1,615,841	
	Project Management			6%	\$96,950	EPA Guidance
	Spra Fin Total				\$1,712,792	

Description:	Assume	50% of injection points will be	used in the second round	d of injections
	Assume	2 platforms with 2 technicia	ans will inject simultaneo	usly to
	Target area (sq.ft) =	27	78,000	32,000
	Average drilling depth =		100	200
	Radius of Influence (ft)=	:	30	
	Number of injection poi	nts (+overlap) =	60	7
	Adverse weather/ no di	g day (days per week) =		0.5
	Injection time (days) =		5	
	Mobe/Demobe (days) =		2	
	Adverse weather/no dig	time (days) =	2	
	Total Working Days =		9	
	Total Travel Days =		13	
	Treatment Duration (we	eeks) =	2	

	Description	Qty	иом	Unit Cost	Total	Notes
	Mobilization/Demobilization	1	LS	\$1,500	\$1,500	Professional Judgment, Pilot Study
	Health and Safety Submission	1	LS	\$500	\$500	Professional Judgment, Pilot Study
Injection Services	Decontamination Pad	2	LS	\$500	\$1,000	Professional Judgment
	Injection Platforms	9	days	\$5,000	\$45,000	Includes injection platforms and other direct costs
	Misc ODC	9	days	\$100	\$900	Professional Judgment
	Decontamination	67	per well	\$100	\$6,700	Vendor Quote, Pilot Study
1011111 111	Delivery/Pickup of 20 cubic yard roll-offs	2	each	\$700	\$1,400	Vendor Quote
IDW Handling	Rental of 20 cubic yard roll off	2	per week	\$300	\$600	Vendor Quote
	Transportation and disposal of IDW roll-offs (assumes non-hazardous)	2	each	\$850	\$1,700	Vendor Quote
Amendment Injections	Water truck, off highway, 6000 gal (2) Sodium permanganate Trucks of 40% sodium permanganate Sales tax	0.5 141,203 3	month per lb per gallon percent	\$29,418 \$1.20 \$80 6.0%	\$14,709 \$169,443 \$269 \$10,183	2016 RSMeans, 01 54 33 6950 Vendor Quote, Pilot Study Vendor Quote, Pilot Study
	Subtotal				\$253,904	
	Bid and Scope Contingency			10%	\$25,390	EPA Guidance
	Spra Fin with Contingency				\$279,294	
	Project Management			8%	\$22,344	EPA Guidance
	Spra Fin Total				\$301,638	

Description:	Assume	25% of injection point	s will be used in the	second roun	d of injections
	Assume	2 platforms with 2	technicians will inje	ct simultaned	ously to
	Target area (sq.ft) =		278,000		32,000
	Average drilling dept	h =	100		200
	Radius of Influence (f	t)=		30	
	Number of injection	points (+overlap) =		30	4
	Adverse weather/ no	dig day (days per week) =			0.5
	Injection time (days)	=		3	
	Mobe/Demobe (days) =		2	
	Adverse weather/no	dig time (days) =		1	
	Total Working Days =			6	
	Total Travel Days =			9	
	Treatment Duration (weeks) =		2	

	Description	Qty	иом	Unit Cost	Total	Notes
	Mobilization/Demobilization	1	LS	\$1,500	\$1,500	Professional Judgment, Pilot Study
	Health and Safety Submission	1	LS	\$500	\$500	Professional Judgment, Pilot Study
Injection Services	Decontamination Pad	2	LS	\$500	\$1,000	Professional Judgment
	Injection Platforms	6	days	\$5,000	\$30,000	Includes injection platforms and other direct costs
	Misc ODC	6	days	\$100	\$600	Professional Judgment
	Decontamination	34	per well	\$100	\$3,400	Vendor Quote, Pilot Study
IDW Handling	Delivery/Pickup of 20 cubic yard roll-offs	2	each	\$700	\$1,400	Vendor Quote
IDW Halluling	Rental of 20 cubic yard roll off	2	per week	\$300	\$600	Vendor Quote
	Transportation and disposal of IDW roll-offs (assumes non-hazardous)	2	each	\$850	\$1,700	Vendor Quote
	Water truck, off highway, 6000 gal (2)	0.5	month	\$29,418	\$14,709	2016 RSMeans, 01 54 33 6950
Amendment	Sodium permanganate	70,601	per lb	\$1.20	\$84,722	Vendor Quote, Pilot Study
Injections	Trucks of 40% sodium permanganate	2	per gallon	\$80	\$134	Vendor Quote, Pilot Study
,	Sales tax		percent	6.0%	\$5,091	
	Subtotal				\$145,357	
	Bid and Scope Contingency			10%	\$14,536	EPA Guidance
	Spra Fin with Contingency				\$159,892	
	Project Management			8%	\$12,791	EPA Guidance
	Spra Fin Total				\$172,684	

Appendix B -Detailed Cost Estimates - Alternative 4 Monitoring Well Installation Component

Description:	12	monitoring wells will be installe	d. Well development time is included.
	8	wells to a depth of	100 ft
	2	wells to a depth of	200 ft
	2	wells to a depth of	500 ft
	Well installation and development (days) =	27	
	Mobe/Demobe (days) =	2	
	Adverse weather/no dig time (days) =	6	
	Total Working Days =	35	
	Total Travel Days =	49	
	Installation Duration (weeks) =	7	

Description	Qty	UOM	Unit Cost	Total	Notes
Mobilization/Demobilization	1	LS	\$1,500	\$1,500	Professional Judgment
Health and Safety Submission	1	LS	\$500	\$500	Professional Judgment
Geologist	35	days	\$800	\$28,000	DOL May 2016 data
Per diem (Geologist)	49	days	\$192	\$9,408	GSA 2018 rates
Decontamination Pad	1	LS	\$500	\$500	Vendor Quote
Drilling Rig	35	days	\$3,000	\$105,000	Vendor Quote
Per Diem (Drilling Crew,2)	49	days	\$384	\$18,816	GSA 2018 rates
55-Gallon Drums	24	each	\$75	\$1,800	Vendor Quote
Well completion	12	LS	\$500	\$6,000	Vendor Quote
Rental Truck	7	weeks	\$350	\$2,450	Online Quote, includes fuel
Misc ODC	35	per day	\$100	\$3,500	Professional Judgment
IDW handling	24	per well	\$75	\$1,800	Vendor Quote, Pilot Study
2-man survey crew	12	per well	\$150	\$1,800	Vendor Quote
Tubing	17	per 100 LF	\$125.00	\$2,128	Vendor Quote
Subtotal				\$183,202	
Bid and Scope Contingency			10%	\$18,320	EPA Guidance
Well Installation with Contingency				\$201,522	
Project Management			5%	\$10,076	EPA Guidance
Well Installation Total				\$211,598	

Description:

45 monitoring wells will be sampled. Taking into account the QC samples, a total of

Quarterly sampling for first year, semi-annual for the next 8 years followed by annual sampling of

8

Samples will be analyzed for VOC, metals, and 1,4-dioxane.

Samples to monitor MNA parameters will be collected the first

3 years.

Wells sampled per day =

One report per year.

30 wells, including QC samples.

60 samples will be collected per event

Description	Qty	иом	Unit Cost	Total	Notes
Groundwater Sampling Event (First year)					
<u></u>					
Disposable Materials per Sample	240	EA	\$25	\$6,000	
PID Meter	6	weeks	\$300	\$1,800	
Water level meter	6	weeks	\$80	\$480	
Multimeter (including turbidity)	6	weeks	\$400	\$2,400	
Pump	6	weeks	\$350	\$2,100	
Misc ODC	32	per day	\$20	\$640	
Rental truck for sample collection	6	weeks	\$400	\$2,400	
Testing, VOC	240	EA	\$47	\$11,280	
Testing, 1,4-dioxane	240	EA	\$90	\$21,600	
Testing, metals	240	EA	\$62	\$14,880	
Testing, MNA	240	EA	\$270	\$64,800	
Data Validation	240	EA	\$33	\$7,920	
Field Crew (2-person)	32	days	\$1,600	\$51,200	
Per Diem (Sampling Crew,2)	32	days	\$384	\$12,288	
Subtotal				\$199,788	
Bid and Scope Contingency			10%	\$19,979	EPA Guidance
First Year Sampling with Contingency				\$219,767	
Project Management			5%	\$10,988	EPA Guidance
First Year Sampling Total				\$230,755	
Groundwater Sampling Event (Baseline Event)					
Disposable Materials per Sample	60	EA .	\$25	\$1,500	
PID Meter	1.5	weeks	\$300	\$450	
Water level meter	1.5	weeks	\$80	\$120	
Multimeter (including turbidity)	1.5	weeks	\$400	\$600	
Pump Misc ODC	1.5 8	weeks	\$350	\$525 \$160	
	1.5	per day weeks	\$20 \$400	\$600	
Rental truck for sample collection	60	EA	\$400 \$47	\$600 \$2,820	
Testing, VOC	60	EA	\$47 \$90	\$2,820 \$5,400	
Testing, 1,4-dioxane Testing, metals	60	EA	\$90 \$62	\$5,400 \$3,720	
Testing, MNA	60	EA	\$270	\$16,200	
Data Validation	60	EA	\$33	\$16,200 \$1,980	
Field Crew (2-person)	8	days	\$1,600	\$1,800	
Per Diem (Sampling Crew,2)	8	days	\$384	\$3,072	
Subtotal	8	uays	-	\$49,947	
Bid and Scope Contingency			10%	\$4,995	EPA Guidance
Baseline Sampling with Contingency				\$54,942	
Project Management			5%	\$2,747	EPA Guidance
Baseline Sampling Total				\$57,689	

Groundwater Sampling Event (Years 2-3)

Disposable Materials per Sample	120	EA	\$25	\$3,000		
PID Meter	3	weeks	\$300	\$900		
Water level meter	3	weeks	\$80	\$240		
Multimeter (including turbidity)	3	weeks	\$400	\$1,200		
Pump	3	weeks	\$350	\$1,050		
Misc ODC	16	per day	\$20	\$320		
Rental truck for sample collection	3	weeks	\$400	\$1,200		
Testing, VOC	120	EA	\$47	\$5,640		
Testing, 1,4-dioxane	120	EA	\$90	\$10,800		
Testing, metals	120	EA	\$62	\$7,440		
Testing, MNA	120	EA	\$270	\$32,400		
Data Validation	120	EA	\$33	\$3,960		
Field Crew (2-person)	16	days	\$1,600	\$25,600		
Per Diem (Sampling Crew,2)	16	days	\$384	\$6,144		
Subtotal				\$99,894		
Bid and Scope Contingency			10%	\$9,989	EPA Guidance	
Vanca 2.2 Consultant of the Constitution				Ć400.003		
Years 2-3 Sampling with Contingency				\$109,883		
Project Management			5%	\$5,494	EPA Guidance	
Years 2-3 Sampling Total				\$115,378		
Groundwater Sampling Event (Year 4-9)						
Disposable Materials per Sample	120	EA	\$25	\$3,000		
PID Meter	3	weeks	\$300	\$900		
Water level meter	3	weeks	\$80	\$240		
Multimeter (including turbidity)	3	weeks	\$400	\$1,200		
Pump	3	weeks	\$350	\$1,050		
Misc ODC	16	per day	\$20	\$320		
Rental truck for sample collection	3	weeks	\$400	\$1,200		
Testing, VOC	120	EA	\$47	\$5,640		
Testing, 1,4-dioxane	120	EA	\$90	\$10,800		
Testing, metals	120	EA	\$62	\$7,440		
Testing, MNA	120	EA	\$270	\$32,400		
Data Validation	120	EA	\$33	\$3,960		
	16		\$1,600	\$25,600		
Field Crew (2-person)		days				
Per Diem (Sampling Crew,2)	16	days	\$384	\$6,144		
Subtotal				\$99,894		
Bid and Scope Contingency			10%	\$9,989	EPA Guidance	
Year 4 Sampling with Contingency				\$109,883		
Project Management			5%	\$5,494	EPA Guidance	
Year 4 Sampling Total				\$115,378		
 				· · ·		

Groundwater Sampling Event (Years 10-30)

Disposable Materials per Sample 30 EA 525 5750 PID Meter 1 weeks 5300 5300 5300 Mate (evel meter 1 weeks 5400	PID Mete Water lev Multimet Pump Misc ODC Rental tri Testing, 7 Testing, 7 Testing, 1 Data Vall Field Cre	ter evel meter eter (including turbidity) CC ruck for sample collection VOC 1,4-dioxane metals MNA lidation	1 1 1 1 8 1 30 30 30	weeks weeks weeks weeks per day weeks EA	\$300 \$80 \$400 \$350 \$20 \$400	\$300 \$80 \$400 \$350 \$160 \$400		
Water level meter	Water lev Multimet Pump Misc ODG Rental trr Testing, \ Testing, \ Testing, I	evel meter eter (including turbidity) CC ruck for sample collection VOC 1,4-dioxane metals MNA lidation	1 1 8 1 30 30 30	weeks weeks weeks per day weeks EA	\$80 \$400 \$350 \$20 \$400	\$80 \$400 \$350 \$160 \$400		
Multimeter (including turbidity) 1 weeks \$400 \$400 Pump 1 weeks \$355 \$350 Misc DOC 8 per day \$20 \$160 Rental truck for sample collection 1 weeks \$400 \$400 Testing, IV-Cl 30 EA \$47 \$1,410 Testing, IV-Gl 30 EA \$90 \$2,700 Testing, MNA 30 EA \$52 \$1,860 Testing, MNA 30 EA \$33 \$590 Field Crew (2-person) 4 days \$384 \$1,536 Subtotal \$10% \$2,544 EPA Guidance Years 5-30 Sampling With Contingency \$10% \$2,544 EPA Guidance Years 5-30 Sampling With Contingency \$10% \$1,399 EPA Guidance Groundwater Monitoring Report (Annual) Project Manager 40 HR \$126 \$5,025 Staff Engineer 60 HR \$105 \$6,775 Staff Scientist 120 HR \$80 \$9,653 <	Multimet Pump Misc ODG Rental tri Testing, J Testing, J Testing, I Data Vall Field Cre	eter (including turbidity) OC ruck for sample collection VOC 1,4-dioxane metals MNA lidation	1 8 1 30 30 30	weeks weeks per day weeks EA	\$400 \$350 \$20 \$400	\$400 \$350 \$160 \$400		
Pump 1 weeks \$350 \$350	Pump Misc ODG Rental tri Testing, J Testing, J Testing, I Data Vali Field Cre	OC ruck for sample collection VOC 1,4-dioxane metals MNA lidation	1 8 1 30 30 30	weeks per day weeks EA	\$350 \$20 \$400	\$350 \$160 \$400		
Misc OBC 8 per day \$20 \$160 Rental Trusk for sample collection 1 weeks \$400 \$400 Testing, 34 discane 30 EA \$47 \$51,410 Testing, 34 discane 30 EA \$52 \$52,00 Testing, 14 discane 30 EA \$52 \$52,00 Testing, metals 30 EA \$52 \$52,00 Data Validation 30 EA \$52 \$52,00 Data Validation 30 EA \$53 \$990 Field Crew (2-person) 4 days \$1,600 \$56,400 Per Diemi (Sampling Crew,2) 4 days \$1,800 \$56,400 Per Diemi (Sampling Crew,2) 4 days \$1,800 \$52,546 Bid and Scope Contingency 10% \$2,544 EPA Guidance Years 5-30 Sampling with Contingency 57,980 Project Management 5% \$1,399 EPA Guidance Years 5-30 Sampling Total \$29,379 Forundwater Monitoring Report (Annual) Project Manager 40 HR \$126 \$5,025 \$1,399 \$1,39	Misc ODO Rental tri Testing, J Testing, J Testing, r Data Vali Field Cre	ruck for sample collection VOC 1,4-dioxane metals MNA lidation	8 1 30 30 30	per day weeks EA	\$20 \$400	\$160 \$400		
Rental truck for sample collection	Rental tri Testing, V Testing, J Testing, r Data Vali Field Cre	ruck for sample collection VOC 1,4-dioxane metals MNA lidation	1 30 30 30	weeks EA	\$400	\$400		
Testing, Vo-discorate	Testing, V Testing, 1 Testing, r Testing, r Data Vali Field Cre	VOC 1,4-dioxane metals MNA lidation	30 30 30	EA				
Testing 1,4-dioxane	Testing, ; Testing, r Testing, l Data Vali Field Cre	1,4-dioxane metals MNA lidation	30 30		\$47			
Testing, metals 30 EA \$62 \$1,860 Testing, MNA 30 EA \$270 \$8,100 Data Validation 30 EA \$233 \$990 Field Crew (2-person) 4 days \$3,600 \$5,400 Per Diem (Sampling Crew,2) 4 days \$3,84 \$1,136 Subtotal \$25,436 Bid and Scope Contingency 10% \$2,544 EPA Guidance Years 5-30 Sampling with Contingency \$27,980 Project Management 5% \$1,399 EPA Guidance Years 5-30 Sampling Total \$29,379 Froject Manager 40 HR \$126 \$5,025 Staff Engineer 60 HR \$105 \$6,277 Staff Scientist 120 HR \$80 \$9,653 QA/QC Officer 40 HR \$70 \$9,2795 Word Processing/Clerical 40 HR \$58 \$5,208 Draftsman/CADD 40 HR \$58 \$5,208 Draftsman/CADD 40 HR \$50 \$5,218 Other Direct Costs 1 LS \$1,00 \$1,00 Subtotal \$28,575 Sub	Testing, r Testing, I Data Vali Field Cre	metals MNA lidation	30	EA		\$1,410		
Testing, MNA	Testing, I Data Vali Field Cre	MNA lidation			\$90	\$2,700		
Data Validation 30	Data Vali Field Cre	lidation	30	EA	\$62	\$1,860		
Field Crew (2-person)	Field Cre		50	EA	\$270	\$8,100		
Per Diem (Sampling Crew,2) 4 days \$384 \$1,536 Subtotal \$25,436 \$25,436 \$25,436 Bid and Scope Contingency 10% \$2,544 EPA Guidance Years 5-30 Sampling with Contingency \$27,980 \$27,980 Froject Management 5% \$1,399 EPA Guidance Groundwater Monitoring Report (Annual) Project Manager 40 HR \$126 \$5,025 Staff Engineer 60 HR \$105 \$6,277 Staff Scientist 120 HR \$80 \$9,653 QA/QC Officer 40 HR \$70 \$2,795 Word Processing/Clerical 40 HR \$56 \$2,308 Draftsman/CADD 40 HR \$60 \$2,418 Other Direct Costs 1 LS \$100 \$100 Subtotal \$28,575 \$28,575 \$28,575		(2)	30	EA	\$33	\$990		
Per Diem (Sampling Crew,2) 4 days \$384 \$1,536 Subtotal \$25,436 \$25,436 \$25,436 Bid and Scope Contingency 10% \$2,544 EPA Guidance Years 5-30 Sampling with Contingency \$27,980 \$27,980 Froject Management 5% \$1,399 EPA Guidance Groundwater Monitoring Report (Annual) Project Manager 40 HR \$126 \$5,025 Staff Engineer 60 HR \$105 \$6,277 Staff Scientist 120 HR \$80 \$9,653 QA/QC Officer 40 HR \$70 \$2,795 Word Processing/Clerical 40 HR \$56 \$2,308 Draftsman/CADD 40 HR \$60 \$2,418 Other Direct Costs 1 LS \$100 \$100 Subtotal \$28,575 \$28,575 \$28,575		ew (z-person)	4	days	\$1,600	\$6,400		
Subtotal S25,436 S25,437 S25,437 S25,4379 S25,4379 S25,4379 S25,437 S25,437	Per Diem		4					
10% \$2,544 EPA Guidance				•	·			
Years 5-30 Sampling with Contingency \$27,980								
Project Management 5% \$1,399 EPA Guidance	Bid and !	Scope Contingency			10%	\$2,544	EPA Guidance	
Project Management 5% \$1,399 EPA Guidance		,				. ,-		
Project Management 5% \$1,399 EPA Guidance	Years 5-?	30 Sampling with Contingency				\$27.980		
Search S		, , , , , , , , , , , , , , , , , , , ,				. ,		
Years 5-30 Sampling Total \$29,379	Project N	Management			5%	\$1,399	EPA Guidance	
Groundwater Monitoring Report (Annual) Project Manager 40 HR \$126 \$5,025 Staff Engineer 60 HR \$105 \$6,277 Staff Scientist 120 HR \$80 \$9,653 QA/QC Officer 40 HR \$70 \$2,795 Word Processing/Clerical 40 HR \$58 \$2,308 Draftsman/CADD 40 HR \$60 \$2,418 Other Direct Costs 1 LS \$100 \$100 Subtotal \$28,575 \$28,575 \$20 \$20	•	•						
Groundwater Monitoring Report (Annual) Project Manager 40 HR \$126 \$5,025 Staff Engineer 60 HR \$105 \$6,277 Staff Scientist 120 HR \$80 \$9,653 QA/QC Officer 40 HR \$70 \$2,795 Word Processing/Clerical 40 HR \$58 \$2,308 Draftsman/CADD 40 HR \$60 \$2,418 Other Direct Costs 1 LS \$100 \$100 Subtotal \$28,575	Years 5-?	30 Sampling Total				\$29,379		
Project Manager 40 HR \$126 \$5,025 Staff Engineer 60 HR \$105 \$6,277 Staff Scientist 120 HR \$80 \$9,653 QA/QC Officer 40 HR \$70 \$2,795 Word Processing/Clerical 40 HR \$58 \$2,308 Draftsman/CADD 40 HR \$60 \$2,418 Other Direct Costs 1 LS \$100 \$100 Subtotal \$28,575								
Project Manager 40 HR \$126 \$5,025 Staff Engineer 60 HR \$105 \$6,277 Staff Scientist 120 HR \$80 \$9,653 QA/QC Officer 40 HR \$70 \$2,795 Word Processing/Clerical 40 HR \$58 \$2,308 Draftsman/CADD 40 HR \$60 \$2,418 Other Direct Costs 1 LS \$100 \$100 Subtotal \$28,575		Groundwater Monitoring Report (Annual)						
Staff Engineer 60 HR \$105 \$6,277 Staff Scientist 120 HR \$80 \$9,653 QA/QC Officer 40 HR \$70 \$2,795 Word Processing/Clerical 40 HR \$58 \$2,308 Draftsman/CADD 40 HR \$60 \$2,418 Other Direct Costs 1 LS \$100 \$100 Subtotal \$28,575								
Staff Engineer 60 HR \$105 \$6,277 Staff Scientist 120 HR \$80 \$9,653 QA/QC Officer 40 HR \$70 \$2,795 Word Processing/Clerical 40 HR \$58 \$2,308 Draftsman/CADD 40 HR \$60 \$2,418 Other Direct Costs 1 LS \$100 \$100 Subtotal \$28,575	Project N	Manager	40	HR	\$126	\$5.025		
Staff Scientist 120 HR \$80 \$9,653 QA/QC Officer 40 HR \$70 \$2,795 Word Processing/Clerical 40 HR \$58 \$2,308 Draftsman/CADD 40 HR \$60 \$2,418 Other Direct Costs 1 LS \$100 \$100 Subtotal \$28,575								
QA/QC Officer 40 HR \$70 \$2,795 Word Processing/Clerical 40 HR \$58 \$2,308 Draftsman/CADD 40 HR \$60 \$2,418 Other Direct Costs 1 LS \$100 \$100 Subtotal \$28,575								
Word Processing/Clerical 40 HR \$58 \$2,308 Draftsman/CADD 40 HR \$60 \$2,418 Other Direct Costs 1 LS \$100 \$100 Subtotal \$28,575								
Draftsman/CADD 40 HR \$60 \$2,418 Other Direct Costs 1 LS \$100 \$100 Subtotal \$28,575								
Other Direct Costs 1 LS \$100 \$100 Subtotal \$28,575								
Subtotal \$28,575								
			-	20	4100			
Bid and Scope Contingency 10% \$2,858 EPA Guidance	Subtotal	•				420,373		
Jan and seepe contingency	Bid and '	Scone Contingency			10%	\$2.858	FPA Guidance	
	Dia una c	scope contingency			10/0	<i>\$2,030</i>	El A Guidance	
Monitoring Report with Contingency \$31,433	Monitor	ring Report with Contingency				\$31.433		
	Womton					402, 733		
Project Management 5% \$1,572 EPA Guidance	Project P	Management			5%	\$1,572	EPA Guidance	
	Projectiv				3/0	41,3,2	21 A Guidance	
riget management 5% \$1,572 EPA Guidalte	Monitor	ring Report Total				\$33,004		
	Wonter	0						

Description:

Tasks included are: document review, site inspection, travel, and reporting. FYRs would be required until the cleanup goals for the Site are achieved Assume quarterly LUC inspections require 1 person for 1/2 day plus reporting

Description	Qty	UOM	Unit Cost	Total	Notes
Five-Year Review + LUC inspections					
Project Manager	40	HR	\$126	\$5,025	
Staff Engineer	60	HR	\$105	\$6,277	
Staff Scientist	80	HR	\$80	\$6,435	
QA/QC Officer	40	HR	\$70	\$2,795	
Word Processing/Clerical	40	HR	\$58	\$2,308	
Draftsman/CADD	40	HR	\$60	\$2,418	
Junior Scientist	80	HR	\$60	\$4,835	
Rental vehicle for LUC inspections	80	day	\$75	\$6,000	
Other Direct Costs	1	LS	\$100	\$100	
Subtotal				\$36,193	
Bid and Scope Contingency			10%	\$3,619 EPA Guidance	
Monitoring Report with Contingency				\$39,812	
Project Management			5%	\$1,991 EPA Guidance	
Monitoring Report Total				\$41,803	

Description:

Assumes a Mid Level Engineers/Scientists would be at the site for the entire duration of injections.

The project manager would be onsite one day per week

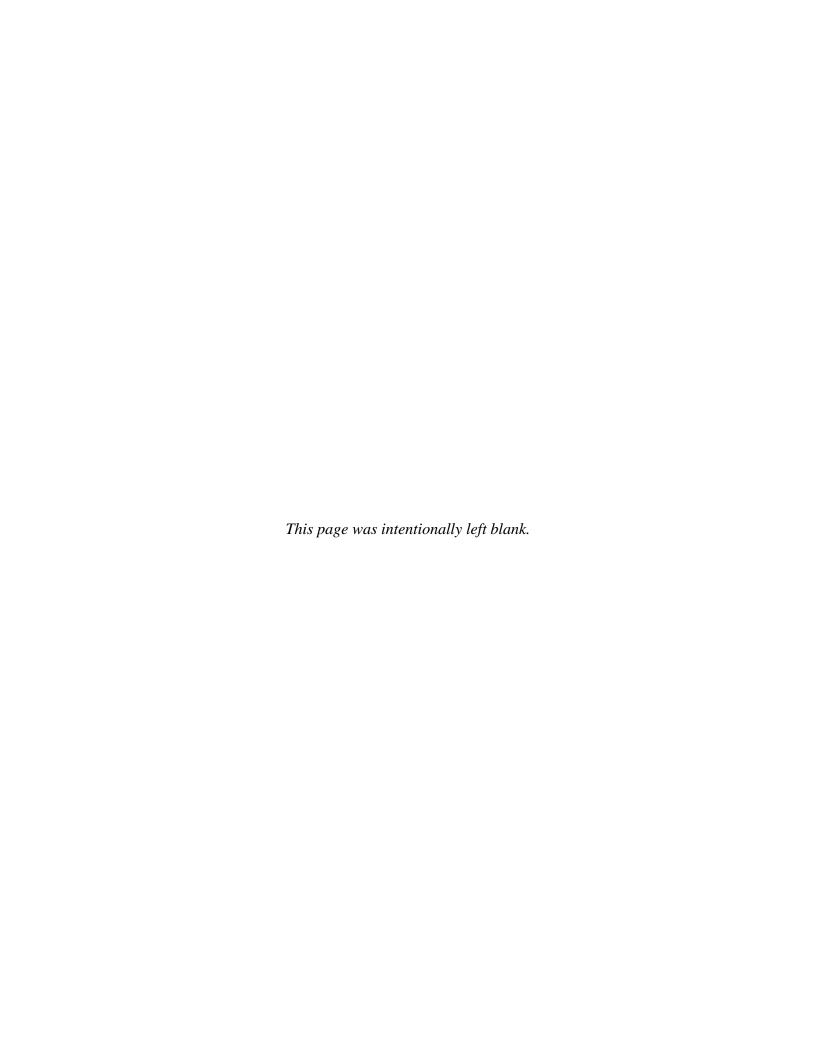
No overlap of injections would occur. Total treatment duration =

22 weeks for the first injection event

6 weeks for the second injection event

5 weeks for the third injection event

	Description	Qty	UOM	Unit Cost		Total	Notes
	Project Manager	220	hour	\$175		\$38,500	
Oversight	, ,		hour				
Oversight	Mid Level Engineer	1210	hour	\$146		\$176,660	
Personnel (1st	Mid Level Scientist	1210	hour	\$130		\$157,300	
event)	Rental Truck	44	weeks	\$350		\$15,400	
	Per diem	308	days	\$384		\$118,272	
					Subtotal	\$506,132	
	Project Manager	60	hour	\$175		\$10,500	
Oversight	Mid Level Engineer	330	hour	\$146		\$48,180	
Personnel (2nd	Mid Level Scientist	330	hour	\$130		\$42,900	
event)	Rental Truck	12	weeks	\$350		\$4,200	
	Per diem	84	days	\$384		\$32,256	
			•		Subtotal	\$138,036	
	Project Manager	50	hour	\$175		\$8,750	
Oversight	Mid Level Engineer	275	hour	\$146		\$40,150	
Personnel (3rd	Mid Level Scientist	275	hour	\$130		\$35,750	
event)	Rental Truck	10	weeks	\$350		\$3,500	
·	Per diem	70	days	\$384		\$26,880	
			/ -	,	Subtotal	\$115,030	



Assumptions

Assume a zone of 50 ft will be injected in each area.

Assume a radius of influence of 30 ft. To account for overlap, a 20% increase to the number of points is assumed.

Each injection point will receive 880 lbs of amendment.

Assume 4.5% by volume of EOS CoBupHMg would be added in the mix.

Area ID	Source Area Footprint (sq. ft.)	Depth Interval (ft bgs)	Targeted zone length (ft)	Number of Injection Points	EOS(lbs)	EOS Solution Volume (gal)	EOS CoBupHMg (gal)	Water (gal, 1:3.5 ratio of EOS)
Teleflex	444,000	100		189	166,320	19,966	898	69,882
Ford	150,000	200		64	56,320	6,761	304	23,664
Facility	130,000	500	50	04	30,320	0,701	304	23,004
Spra Fin	278,000	100		119	104,720	12,571	566	44,000
Spra Fin 2	32,000	200		14	12,320	1,479	67	5,176
	Total			386	339,680	40,778	1,835	142,723

Description: Assume 3 rigs working simultaneously to drill injection points with two technicians in each rig.

Assume 2 platforms with 2 technicians will inject simultaneously to 8 injection points.

8

Target area (sq.ft) = 444,000

Average drilling depth = 100

Padius of Influence for FOS (ft) =

Radius of Influence for EOS (ft)= 30

Number of injection points (+overlap) = 189

Assume drilling rate (LF/hour) = 50

Assume time for completion of point (hr/point) =

Assume time for completion of point (hr/point) = 0.25 Adverse weather/ no dig day (days per week) = 0.5

Drilling time (days) = 16
Injection time (days) = 12
Mobe/Demobe (days) = 2
Completion time (days) = 2
Adverse weather/no dig time (days) = 7
Total Working Days = 39
Total Travel Days = 55

Treatment Duration (weeks) =

	Description	Qty	иом	Unit Cost	Total	Notes
	Mobilization/Demobilization	1	LS	\$3,500	\$3,500	Professional Judgment, Pilot Study
	Health and Safety Submission	1	LS	\$1,500	\$1,500	Professional Judgment, Pilot Study
	Borehole Drilling (6")	18,900	per ft	\$62	\$1,171,800	Vendor Quote
-	Borehole Completion	189	per well	\$250	\$47,250	Vendor Quote
,	Decontamination Pad	5	LS	\$500	\$2,500	Professional Judgment
	Injection Platforms	12	days	\$5,000	\$60,000	Includes injection platforms and other direct costs
	Misc ODC	39	days	\$100	\$3,900	Professional Judgment
	L			4	4	
	Decontamination	189	per well	\$100	\$18,900	Vendor Quote, Pilot Study
	Delivery/Pickup of 20 cubic yard roll-offs	27	each	\$700	\$19,233	Vendor Quote
IDW	Rental of 20 cubic yard roll off	8	per week	\$300	\$2,400	Vendor Quote
Handling	Transportation and disposal of IDW roll-offs (assumes non-hazardous)	27	each	\$850	\$23,354	Vendor Quote
	Delivery/Pickup of 21,000 gallon fraq tank	1	each	\$1,000	\$1,000	Vendor Quote
	Rental of 21,000 gallon fraq tank	55	per day	\$35	\$1,925	Vendor Quote
	Transportation and disposal of IDW liquid (non-hazardous)	21,000	per gallon	\$0.25	\$5,250	Vendor Quote
	Water truck, off highway, 6000 gal (2)	2	month	\$29,418	\$58,836	2016 RSMeans, 01 54 33 6950, includes water cost
Amendment	EOS PRO	166,320	per lb	\$1.20	\$199,584	Vendor Quote, Pilot Study
Injections	EOS CoBupHMg	898	per gallon	\$80	\$71,879	Vendor Quote, Pilot Study
-	Sales tax		percent	6.0%	\$16,288	•
	Subtotal				\$1,709,098	
	Bid and Scope Contingency			20%	\$341,820	EPA Guidance
	Teleflex with Contingency				\$2,050,918	
	Project Management			6%	\$123,055	EPA Guidance
	Teleflex Total				\$2,173,973	

Description: Assume 50% of injection points will be used in the second round of injections

Assume 2 platforms with 2 technicians will inject simultaneously to 8 injection points.

Target area (sq.ft) = 444,000 Average drilling depth = 100 Radius of Influence for EOS (ft)= 30 Number of injection points (+overlap) = 95 6 Injection time (days) = Mobe/Demobe (days) = 2 Adverse weather/no dig time (days) = 2 Total Working Days = 10 Total Travel Days = 14 Treatment Duration (weeks) = 2

	Description	Qty	UOM	Unit Cost	Total	Notes
	Mobilization/Demobilization	1	LS	\$1,500	\$1,500	Professional Judgment, Pilot Study
Inication	Health and Safety Submission	1	LS	\$500	\$500	Professional Judgment, Pilot Study
Injection Services	Decontamination Pad	2	LS	\$500	\$1,000	Professional Judgment
Services	Injection Platforms	10	days	\$5,000	\$50,000	Includes injection platforms and other direct costs
	Misc ODC	10	days	\$100	\$1,000	Professional Judgment
	Decontamination	95	per well	\$100	\$9,500	Vendor Quote, Pilot Study
IDW	Delivery/Pickup of 20 cubic yard roll-offs (2)	2	each	\$700	\$1,400	Vendor Quote
Handling	Rental of 20 cubic yard roll off	2	per week	\$300	\$600	Vendor Quote
	Transportation and disposal of IDW roll-offs (assumes non-hazardous)	2	each	\$850	\$1,700	Vendor Quote
	Water truck, off highway, 6000 gal (2)	0.5	month	\$29,418	\$14,709	2016 RSMeans, 01 54 33 6950, includes water cost
Amendment	EOS PRO	83,160	per lb	\$1.20	\$99,792	Vendor Quote, Pilot Study
Injections	EOS CoBupHMg	449	per gallon	\$80	\$35,939	Vendor Quote, Pilot Study
	Sales tax		percent	6.0%	\$8,144	
	Subtotal				\$225,784	
	Bid and Scope Contingency			20%	\$45,157	EPA Guidance
	Teleflex with Contingency				\$270,941	
	Project Management			8%	\$21,675	EPA Guidance
	Teleflex Total				\$292,617	

Description: Assume 3 rigs working simultaneously to drill injection points with two technicians in each rig.

Assume 2 platforms with 2 technicians will inject simultaneously to 5 injection points.

Target area (sq.ft) = 150,000 Average drilling depth = Radius of Influence for EOS (ft)= 30 Number of injection points (+overlap) = 64 Assume drilling rate (LF/hour) = Assume time for completion of point (hr/point) = 0.25 Adverse weather/ no dig day (days per week) = 0.5 Drilling time (days) = 19 Injection time (days) = 7 Mobe/Demobe (days) = 2 Completion time (days) = Adverse weather/no dig time (days) = 6 Total Working Days = 35 49 Total Travel Days = Treatment Duration (weeks) = 7

	Description	Qty	UOM	Unit Cost	Total	Notes
	Mobilization/Demobilization	1	LS	\$3,500	\$3,500	Professional Judgment, Pilot Study
	Health and Safety Submission	1	LS	\$1,500	\$1,500	Professional Judgment, Pilot Study
Drilling and	Borehole Drilling (6")	22,400	per ft	\$62	\$1,388,800	Vendor Quote
Injection	Borehole Completion	64	per well	\$250	\$16,000	Vendor Quote
Services	Decontamination Pad	5	LS	\$500	\$2,500	Professional Judgment
	Injection Platforms	7	days	\$5,000	\$35,000	Includes injection platforms and other direct costs
	Misc ODC	35	days	\$100	\$3,500	Professional Judgment
	Decontamination	64	per well	\$100	\$6,400	Vendor Quote, Pilot Study
	Delivery/Pickup of 20 cubic yard roll-offs	33	each	\$700	\$23,100	Vendor Quote
	Rental of 20 cubic yard roll off	7	per week	\$300	\$2,100	Vendor Quote
IDW	Transportation and disposal of IDW roll-offs (assumes non-hazardous)	33	each	\$850	\$28,050	Vendor Quote
Handling	Delivery/Pickup of 21,000 gallon fraq tank	1	each	\$1,000	\$1,000	Vendor Quote
	Rental of 21,000 gallon fraq tank	49	per day	\$35	\$1,715	Vendor Quote
	Transportation and disposal of IDW liquid (non-hazardous)	21,000	per gallon	\$0.25	\$5,250	Vendor Quote
	Water truck, off highway, 6000 gal (2)	1.75	month	\$29,418	\$51,482	2016 RSMeans, 01 54 33 6950
Amendment	EOS PRO	56,320	per lb	\$1.20	\$67,584	Vendor Quote, Pilot Study
Injections	EOS CoBupHMg	304	per gallon	\$80	\$24,340	Vendor Quote, Pilot Study
	Sales tax		percent	6.0%	\$5,515	
	Subtotal				\$1,667,336	
	Bid and Scope Contingency			20%	\$333,467	EPA Guidance
	Ford Facility with Contingency				\$2,000,803	
	Project Management			5%	\$100,040	EPA Guidance
	Ford Facility Total				\$2,100,843	

Description: Assume 50% of injection points will be used in the second round of injections

Assume 2 platforms with 2 technicians will inject simultaneously to

12

2

0.5

Target area (sq.ft) = 150,000 Average drilling depth = 350 30 Radius of Influence for EOS (ft)= Number of injection points (+overlap) = 32 Adverse weather/ no dig day (days per week) = Injection time (days) = 2 Mobe/Demobe (days) = Adverse weather/no dig time (days) = 2 Total Working Days = 8

Total Travel Days =

Treatment Duration (weeks) =

	Description	Qty	иом	Unit Cost	Total	Notes
	Mobilization/Demobilization	1	LS	\$1,500	\$1,500	Professional Judgment, Pilot Study
	Health and Safety Submission	1	LS	\$500	\$500	Professional Judgment, Pilot Study
Injection	Decontamination Pad	2	LS	\$500	\$1,000	Professional Judgment
Services	Injection Platforms	4	days	\$5,000	\$20,000	Includes injection platforms and other direct
	Misc ODC	8	days	\$100	\$800	Professional Judgment
	Decontamination	32	per well	\$100	\$3,200	Vendor Quote, Pilot Study
OW Handling	Delivery/Pickup of 20 cubic yard roll-offs	2	each	\$700	\$1,400	Vendor Quote
Jvv nanunng	Rental of 20 cubic yard roll off	2	per week	\$300	\$600	Vendor Quote
	Transportation and disposal of IDW roll-offs (assumes non-hazardous)	2	each	\$850	\$1,700	Vendor Quote
	Water truck, off highway, 6000 gal (2)	0.5	month	\$29,418	\$14,709	2016 RSMeans, 01 54 33 6950
Amendment	EOS PRO	28,160	per lb	\$1.20	\$33,792	Vendor Quote, Pilot Study
Injections	EOS CoBupHMg	152	per gallon	\$80	\$12,170	Vendor Quote, Pilot Study
	Sales tax		percent	6.0%	\$2,758	
	Subtotal				\$94,129	
	Bid and Scope Contingency			20%	\$18,826	EPA Guidance
	Ford Facility with Contingency				\$112,954	
	Project Management			8%	\$9,036	EPA Guidance
	Ford Facility Total				\$121,991	

Assume 2 platforms with 2 technicians will inject simultaneously to 8 injection point	S.
Target area (sq.ft) = 278,000 32,000	
Average drilling depth = 100 200	
Radius of Influence for EOS (ft)= 30	
Number of injection points (+overlap) = 119 14	
Assume drilling rate (LF/hour) = 50	
Assume time for completion of point (hr/point) = 0.25	
Adverse weather/ no dig day (days per week) = 0.5	
Drilling time (days) = 13	
Injection time (days) = 9	
Mobe/Demobe (days) = 2	
Completion time (days) = 2	
Adverse weather/no dig time (days) = 6	
Total Working Days = 32	
Total Travel Days = 45	
Treatment Duration (weeks) = 7	

·	Description	Qty	иом	Unit Cost	Total	Notes
	Mobilization/Demobilization	1	LS	\$3,500	\$3,500	Professional Judgment, Pilot Study
	Health and Safety Submission	1	LS	\$1,500	\$1,500	Professional Judgment, Pilot Study
Drilling and	Borehole Drilling (6")	14700	per ft	\$62	\$911,400	Vendor Quote
Injection	Borehole Completion	133	per well	\$250	\$33,250	Vendor Quote
Services	Decontamination Pad	5	LS	\$500	\$2,500	Professional Judgment
	Injection Platforms	9	days	\$5,000	\$45,000	Includes injection platforms and other direct of
	Misc ODC	32	days	\$100	\$3,200	Professional Judgment
	Decontamination	133	per well	\$100	\$13,300	Vendor Quote, Pilot Study
	Delivery/Pickup of 20 cubic yard roll-offs	22	each	\$700	\$15,400	Vendor Quote
IDW	Rental of 20 cubic yard roll off	7	per week	\$300	\$2,100	Vendor Quote
Handling	Transportation and disposal of IDW roll-offs (assumes non-hazardous)	22	each	\$850	\$18,700	Vendor Quote
Handing	Delivery/Pickup of 21,000 gallon fraq tank	1	each	\$1,000	\$1,000	Vendor Quote
	Rental of 21,000 gallon fraq tank	45	per day	\$35	\$1,575	Vendor Quote
	Transportation and disposal of IDW liquid (non-hazardous)	21,000	per gallon	\$0.25	\$5,250	Vendor Quote
	Water truck, off highway, 6000 gal (2)	1.75	month	\$29,418	\$51,482	2016 RSMeans, 01 54 33 6950
Amendment		117,040	per lb	\$1.20	\$140,448	Vendor Quote, Pilot Study
	EOS CoBupHMg	632	per gallon	\$80	\$50,582	Vendor Quote, Pilot Study
-	Sales tax		percent	6.0%	\$11,462	
	Subtotal		, , , , , , , , , , , , , , , , , , , ,		\$1,311,648	
	Bid and Scope Contingency			10%	\$131,165	EPA Guidance
	Spra Fin with Contingency				\$1,442,813	
	Project Management			6%	\$86,569	EPA Guidance
	Spra Fin Total				\$1,529,381	

Description: Assume 50% of injection points will be used in the second round of injections
Assume 2 platforms with 2 technicians will inject simultaneously to 8 injection points.

Target area (sq.ft) = 278,000 32,000 Average drilling depth = 100 200 Radius of Influence for EOS (ft)= 30 7 Number of injection points (+overlap) = 60 Adverse weather/ no dig day (days per week) = 0.5 Injection time (days) = 5 Mobe/Demobe (days) = 2 Adverse weather/no dig time (days) = 2 Total Working Days = 9 Total Travel Days = 13 Treatment Duration (weeks) = 2

	Description	Qty	UOM	Unit Cost	Total	Notes
	Mobilization/Demobilization	1	LS	\$1,500	\$1,500	Professional Judgment, Pilot Study
1.1	Health and Safety Submission	1	LS	\$500	\$500	Professional Judgment, Pilot Study
Injection	Decontamination Pad	2	LS	\$500	\$1,000	Professional Judgment
Services	Injection Platforms	9	days	\$5,000	\$45,000	Includes injection platforms and other direct co
	Misc ODC	9	days	\$100	\$900	Professional Judgment
	Decontamination	67	per well	\$100	\$6,700	Vendor Quote, Pilot Study
N Handling	Delivery/Pickup of 20 cubic yard roll-offs	2	each	\$700	\$1,400	Vendor Quote
v nanunng	Rental of 20 cubic yard roll off	2	per week	\$300	\$600	Vendor Quote
	Transportation and disposal of IDW roll-offs (assumes non-hazardous)	2	each	\$850	\$1,700	Vendor Quote
	Water truck, off highway, 6000 gal (2)	0.5	month	\$29,418	\$14,709	2016 RSMeans, 01 54 33 6950
nendment	EOS PRO	58,520	per lb	\$1.20	\$70,224	Vendor Quote, Pilot Study
njections	EOS CoBupHMg	316	per gallon	\$80	\$25,291	Vendor Quote, Pilot Study
	Sales tax		percent	6.0%	\$5,731	
	Subtotal				\$175,255	
	Bid and Scope Contingency			10%	\$17,525	EPA Guidance
	Spra Fin with Contingency				\$192,780	
	Project Management			8%	\$15,422	EPA Guidance
	Spra Fin Total				\$208,203	

Description:	12	monitoring wells will be	installed. We	ell developmer	nt time is included.		
	8	wells to a depth of	100 ft	•			
	2	wells to a depth of	200 ft				
	2	wells to a depth of	500 ft				
	Well installation and development (days) =	27	300 11				
	Mobe/Demobe (days) =	2					
	Adverse weather/no dig time (days) =	6					
	Total Working Days =	35					
	Total Travel Days =	49					
	Installation Duration (weeks) =	7					
	Description		Qty	UOM	Unit Cost	Total	Notes
	Mobilization/Demobilization		1	LS	\$1,500	\$1,500	Professional Judg
	Health and Safety Submission		1	LS	\$500	\$500	Professional Judg
	Geologist		35	days	\$800	\$28,000	DOL May 2016 da
	Per diem (Geologist)		49	days	\$192	\$9,408	GSA 2018 rates
	Decontamination Pad		1	LS	\$500	\$500	Vendor Quote
	Drilling Rig		35	days	\$3,000	\$105,000	Vendor Quote
	Per Diem (Drilling Crew,2)		49	days	\$384	\$18,816	GSA 2018 rates
	55-Gallon Drums		24	each	\$75	\$1,800	Vendor Quote
	Well completion		12	LS	\$500	\$6,000	Vendor Quote
	Rental Truck		7	weeks	\$350	\$2,450	Online Quote, inc
	Misc ODC		35	per day	\$100	\$3,500	Professional Judg
	IDW handling		24	per well	\$75	\$1,800	Vendor Quote, Pi
	2-man survey crew		12	per well	\$150	\$1,800	Vendor Quote
	Tubing		17	per 100 LF	\$125.00	\$2,128	Vendor Quote
	Subtotal					\$183,202	
	Bid and Scope Contingency				10%	\$18,320	EPA Guidance
	Well Installation with Contingency					\$201,522	
	Project Management				5%	\$10,076	EPA Guidance
	Well Installation Total					\$211,598	

- Alternative 5 tallation Component

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Appendix B -Detailed Cost Estimates - Alternative 5 Long Term Monitoring Component

Description:

45 monitoring wells will be sampled. Taking into account the QC samples, a total of

Samples will be analyzed for VOC, metals, and 1,4-dioxane.

Samples to monitor MNA parameters will be collected the first 3 years.

Wells sampled per day =

One report per year.

Quarterly sampling for first year, semi-annual for the next 3 years followed by annual sampling of

30 wells, including QC samples.

60 samples will be collected per event

Description	Qty	UOM	Unit Cost	Total	Notes
Groundwater Sampling Event (First year)					
Disposable Materials per Sample	240	EA	\$25	\$6,000	Site Experience
PID Meter	6	weeks	\$300	\$1,800	Vendor Online Catalogue
Water level meter	6	weeks	\$80	\$480	Vendor Online Catalogue
Multimeter (including turbidity)	6	weeks	\$400	\$2,400	Vendor Online Catalogue
Pump	6	weeks	\$350	\$2,100	Vendor Online Catalogue
Misc ODC	32	per day	\$20	\$640	Professional Judgment
Rental truck for sample collection	6	weeks	\$400	\$2,400	Online Quote, includes fuel
Testing, VOC	240	EA	\$47	\$11,280	Site Experience
Testing, 1,4-dioxane	240	EA	\$90	\$21,600	Site Experience
Testing, metals	240	EA	\$62	\$14,880	Site Experience
Testing, MNA	240	EA	\$270	\$64,800	Site Experience
Data Validation	240	EA	\$33	\$7,920	Site Experience
Field Crew (2-person)	32	days	\$1,600	\$51,200	Site Experience
Per Diem (Sampling Crew,2)	32	days	\$384	\$12,288	GSA 2018 rates
Subtotal				\$199,788	
Bid and Scope Contingency			10%	\$19,979	EPA Guidance
First Year Sampling with Contingency				\$219,767	
Project Management			5%	\$10,988	EPA Guidance
First Year Sampling Total				\$230,755	

Groundwater Sampling Event (Baseline Event)

Disposable Materials per Sample	60	EA	\$25	\$1,500	Site Experience
PID Meter	1.5	weeks	\$300	\$450	Vendor Online Catalogue
Water level meter	1.5	weeks	\$80	\$120	Vendor Online Catalogue
Multimeter (including turbidity)	1.5	weeks	\$400	\$600	Vendor Online Catalogue
Pump	1.5	weeks	\$350	\$525	Vendor Online Catalogue
Misc ODC	8	per day	\$20	\$160	Professional Judgment
Rental truck for sample collection	1.5	weeks	\$400	\$600	Online Quote, includes fuel
Testing, VOC	60	EA	\$47	\$2,820	Site Experience
Testing, 1,4-dioxane	60	EA	\$90	\$5,400	Site Experience
Testing, metals	60	EA	\$62	\$3,720	Site Experience
Testing, MNA	60	EA	\$270	\$16,200	Site Experience
Data Validation	60	EA	\$33	\$1,980	Site Experience
	8		•		
Field Crew (2-person)		days	\$1,600	\$12,800	Site Experience
Per Diem (Sampling Crew,2)	8	days	\$384	\$3,072	GSA 2018 rates
Subtotal				\$49,947	
Bid and Scope Contingency			10%	\$4,995	EPA Guidance
Baseline Sampling with Contingency				\$54,942	
,				7- 7	
Project Management			5%	\$2,747	EPA Guidance
Baseline Sampling Total				\$57,689	
Groundwater Sampling Event (Years 2-3)					
Disposable Materials per Sample	120	EA	\$25	\$3,000	Site Experience
PID Meter	3	weeks	\$300	\$900	Vendor Online Catalogue
Water level meter	3	weeks	\$80	\$240	Vendor Online Catalogue
Multimeter (including turbidity)	3	weeks	\$400	\$1,200	Vendor Online Catalogue
Pump	3	weeks	\$350	\$1,050	Vendor Online Catalogue
Misc ODC	16	per day	\$20	\$320	Professional Judgment
Rental truck for sample collection	3	weeks	\$400	\$1,200	Online Quote, includes fuel
Testing, VOC	120	EA	\$47	\$5,640	Site Experience
Testing, 1,4-dioxane	120	EA	\$90	\$10,800	Site Experience
Testing, metals	120	EA	\$62	\$7,440	Site Experience
Testing, MNA	120	EA	\$270	\$32,400	Site Experience
Data Validation	120	EA	\$33	\$3,960	Site Experience
Field Crew (2-person)	16	days	\$1,600	\$25,600	Site Experience
Per Diem (Sampling Crew,2)	16	days	\$384	\$6,144	GSA 2018 rates
Subtotal				\$99,894	
Bid and Scope Contingency			10%	\$9,989	EPA Guidance
Years 2-3 Sampling with Contingency				\$109,883	
Project Management			5%	\$5,494	EPA Guidance
Years 2-3 Sampling Total				\$115,378	
				7115,570	

Groundwater Sampling Event (Year 4)

Disposable Materials per Cample					
Disposable Materials per Sample	120	EA	\$25	\$3,000	Site Experience
PID Meter	3	weeks	\$300	\$900	Vendor Online Catalogue
Water level meter	3	weeks	\$80	\$240	Vendor Online Catalogue
Multimeter (including turbidity)	3	weeks	\$400	\$1,200	Vendor Online Catalogue
Pump	3	weeks	\$350	\$1,050	Vendor Online Catalogue
Misc ODC	16	per day	\$20	\$320	Professional Judgment
Rental truck for sample collection	3	weeks	\$400	\$1,200	Online Quote, includes fuel
Testing, VOC	120	EA	\$47	\$5,640	Site Experience
Testing, 1,4-dioxane	120	EA	\$90	\$10,800	Site Experience
Testing, metals	120	EA	\$62	\$7,440	Site Experience
Data Validation	120	EA	\$33	\$3,960	Site Experience
Field Crew (2-person)	16	days	\$1,600	\$25,600	Site Experience
Per Diem (Sampling Crew,2)	16	days	\$384	\$6,144	GSA 2018 rates
Subtotal				\$67,494	
Bid and Scope Contingency			10%	\$6,749	EPA Guidance
Year 4 Sampling with Contingency				\$74,243	
Project Management			5%	\$3,712	EPA Guidance
Year 4 Sampling Total				\$77,956	
Groundwater Sampling Event (Years 5-30)					
Groundwater Sumpling Event (Tears 3-30)					
Disposable Materials per Sample	30	EA	\$25	\$750	Site Experience
PID Meter	1	weeks	\$300	\$300	Vendor Online Catalogue
					vendor oninie editarogue
Water level meter	1	weeks	\$80	\$80	Vendor Online Catalogue
Water level meter Multimeter (including turbidity)	1	weeks weeks	\$80 \$400		_
	1 1		·	\$80	Vendor Online Catalogue
Multimeter (including turbidity) Pump Misc ODC	1 1 8	weeks weeks per day	\$400 \$350 \$20	\$80 \$400 \$350 \$160	Vendor Online Catalogue Vendor Online Catalogue Vendor Online Catalogue Professional Judgment
Multimeter (including turbidity) Pump Misc ODC Rental truck for sample collection	1 1 8 1	weeks weeks per day weeks	\$400 \$350 \$20 \$400	\$80 \$400 \$350 \$160 \$400	Vendor Online Catalogue Vendor Online Catalogue Vendor Online Catalogue
Multimeter (including turbidity) Pump Misc ODC Rental truck for sample collection Testing, VOC	1 1 8 1 30	weeks weeks per day weeks EA	\$400 \$350 \$20 \$400 \$47	\$80 \$400 \$350 \$160 \$400 \$1,410	Vendor Online Catalogue Vendor Online Catalogue Vendor Online Catalogue Professional Judgment Online Quote, includes fuel Site Experience
Multimeter (including turbidity) Pump Misc ODC Rental truck for sample collection Testing, VOC Testing, 1,4-dioxane	1 1 8 1 30 30	weeks weeks per day weeks EA EA	\$400 \$350 \$20 \$400 \$47 \$90	\$80 \$400 \$350 \$160 \$400 \$1,410 \$2,700	Vendor Online Catalogue Vendor Online Catalogue Vendor Online Catalogue Professional Judgment Online Quote, includes fuel Site Experience Site Experience
Multimeter (including turbidity) Pump Misc ODC Rental truck for sample collection Testing, VOC Testing, 1,4-dioxane Testing, metals	1 1 8 1 30 30 30	weeks weeks per day weeks EA EA	\$400 \$350 \$20 \$400 \$47 \$90 \$62	\$80 \$400 \$350 \$160 \$400 \$1,410 \$2,700 \$1,860	Vendor Online Catalogue Vendor Online Catalogue Vendor Online Catalogue Professional Judgment Online Quote, includes fuel Site Experience Site Experience Site Experience
Multimeter (including turbidity) Pump Misc ODC Rental truck for sample collection Testing, VOC Testing, 1,4-dioxane Testing, metals Testing, MNA	1 1 8 1 30 30 30 30	weeks weeks per day weeks EA EA EA	\$400 \$350 \$20 \$400 \$47 \$90 \$62 \$270	\$80 \$400 \$350 \$160 \$400 \$1,410 \$2,700 \$1,860 \$8,100	Vendor Online Catalogue Vendor Online Catalogue Vendor Online Catalogue Professional Judgment Online Quote, includes fuel Site Experience Site Experience Site Experience Site Experience
Multimeter (including turbidity) Pump Misc ODC Rental truck for sample collection Testing, VOC Testing, 1,4-dioxane Testing, metals Testing, MNA Data Validation	1 1 8 1 30 30 30 30 30 30	weeks weeks per day weeks EA EA EA EA	\$400 \$350 \$20 \$400 \$47 \$90 \$62 \$270 \$33	\$80 \$400 \$350 \$160 \$400 \$1,410 \$2,700 \$1,860 \$8,100 \$990	Vendor Online Catalogue Vendor Online Catalogue Vendor Online Catalogue Professional Judgment Online Quote, includes fuel Site Experience Site Experience Site Experience Site Experience Site Experience Site Experience
Multimeter (including turbidity) Pump Misc ODC Rental truck for sample collection Testing, VOC Testing, 1,4-dioxane Testing, metals Testing, MNA Data Validation Field Crew (2-person)	1 1 8 1 30 30 30 30 30 30 4	weeks weeks per day weeks EA EA EA EA A EA A EA A A A A A A A A	\$400 \$350 \$20 \$400 \$47 \$90 \$62 \$270 \$33 \$1,600	\$80 \$400 \$350 \$160 \$400 \$1,410 \$2,700 \$1,860 \$8,100 \$990 \$6,400	Vendor Online Catalogue Vendor Online Catalogue Vendor Online Catalogue Professional Judgment Online Quote, includes fuel Site Experience
Multimeter (including turbidity) Pump Misc ODC Rental truck for sample collection Testing, VOC Testing, 1,4-dioxane Testing, metals Testing, MNA Data Validation Field Crew (2-person) Per Diem (Sampling Crew,2)	1 1 8 1 30 30 30 30 30 30	weeks weeks per day weeks EA EA EA EA	\$400 \$350 \$20 \$400 \$47 \$90 \$62 \$270 \$33	\$80 \$400 \$350 \$160 \$400 \$1,410 \$2,700 \$1,860 \$8,100 \$990 \$6,400 \$1,536	Vendor Online Catalogue Vendor Online Catalogue Vendor Online Catalogue Professional Judgment Online Quote, includes fuel Site Experience Site Experience Site Experience Site Experience Site Experience Site Experience
Multimeter (including turbidity) Pump Misc ODC Rental truck for sample collection Testing, VOC Testing, 1,4-dioxane Testing, metals Testing, MNA Data Validation Field Crew (2-person)	1 1 8 1 30 30 30 30 30 30 4	weeks weeks per day weeks EA EA EA EA A EA A EA A A A A A A A A	\$400 \$350 \$20 \$400 \$47 \$90 \$62 \$270 \$33 \$1,600	\$80 \$400 \$350 \$160 \$400 \$1,410 \$2,700 \$1,860 \$8,100 \$990 \$6,400	Vendor Online Catalogue Vendor Online Catalogue Vendor Online Catalogue Professional Judgment Online Quote, includes fuel Site Experience
Multimeter (including turbidity) Pump Misc ODC Rental truck for sample collection Testing, VOC Testing, 1,4-dioxane Testing, metals Testing, MNA Data Validation Field Crew (2-person) Per Diem (Sampling Crew,2)	1 1 8 1 30 30 30 30 30 30 4	weeks weeks per day weeks EA EA EA EA A EA A EA A A A A A A A A	\$400 \$350 \$20 \$400 \$47 \$90 \$62 \$270 \$33 \$1,600	\$80 \$400 \$350 \$160 \$400 \$1,410 \$2,700 \$1,860 \$8,100 \$990 \$6,400 \$1,536	Vendor Online Catalogue Vendor Online Catalogue Vendor Online Catalogue Professional Judgment Online Quote, includes fuel Site Experience
Multimeter (including turbidity) Pump Misc ODC Rental truck for sample collection Testing, VOC Testing, 1,4-dioxane Testing, metals Testing, MNA Data Validation Field Crew (2-person) Per Diem (Sampling Crew,2) Subtotal	1 1 8 1 30 30 30 30 30 30 4	weeks weeks per day weeks EA EA EA EA A EA A EA A A A A A A A A	\$400 \$350 \$20 \$400 \$47 \$90 \$62 \$270 \$33 \$1,600 \$384	\$80 \$400 \$350 \$160 \$400 \$1,410 \$2,700 \$1,860 \$8,100 \$990 \$6,400 \$1,536 \$25,436	Vendor Online Catalogue Vendor Online Catalogue Vendor Online Catalogue Professional Judgment Online Quote, includes fuel Site Experience
Multimeter (including turbidity) Pump Misc ODC Rental truck for sample collection Testing, VOC Testing, 1,4-dioxane Testing, metals Testing, MNA Data Validation Field Crew (2-person) Per Diem (Sampling Crew,2) Subtotal Bid and Scope Contingency	1 1 8 1 30 30 30 30 30 30 4	weeks weeks per day weeks EA EA EA EA A EA A EA A A A A A A A A	\$400 \$350 \$20 \$400 \$47 \$90 \$62 \$270 \$33 \$1,600 \$384	\$80 \$400 \$350 \$160 \$400 \$1,410 \$2,700 \$1,860 \$8,100 \$990 \$6,400 \$1,536 \$25,436	Vendor Online Catalogue Vendor Online Catalogue Vendor Online Catalogue Professional Judgment Online Quote, includes fuel Site Experience

Groundwater Monitoring Report (Annual)

Project Manager	40	HR	\$126	\$5,025
Staff Engineer	60	HR	\$105	\$6,277
Staff Scientist	120	HR	\$80	\$9,653
QA/QC Officer	40	HR	\$70	\$2,795
Word Processing/Clerical	40	HR	\$58	\$2,308
Draftsman/CADD	40	HR	\$60	\$2,418
Other Direct Costs	1	LS	\$100	\$100
Subtotal				\$28,575
Bid and Scope Contingency			10%	\$2,858 EPA Guidance
Monitoring Report with Contingency				\$31,433
Project Management			5%	\$1,572 EPA Guidance
Monitoring Report Total				\$33,004

Description: Tasks included are: document review, site inspection, travel, and reporting.

FYRs would be required until the cleanup goals for the Site are achieved

Assume quarterly LUC inspections require 1 person for 1/2 day plus reporting

Description	Qty	UOM	Unit Cost	Total	Notes
Five-Year Review + LUC inspections					
Project Manager	40	HR	\$126	\$5,025	
Staff Engineer	60	HR	\$105	\$6,277	
Staff Scientist	80	HR	\$80	\$6,435	
QA/QC Officer	40	HR	\$70	\$2,795	
Word Processing/Clerical	40	HR	\$58	\$2,308	
Draftsman/CADD	40	HR	\$60	\$2,418	
Junior Scientist	80	HR	\$60	\$4,835	
Rental vehicle for LUC inspections	80	day	\$75	\$6,000	
Other Direct Costs	1	LS	\$100	\$100	
Subtotal	1	L	\$100	\$36 ,193	
Subtotal				330,133	
Bid and Scope Contingency			10%	\$3,619	EPA Guidance
Monitoring Report with Contingency				\$39,812	
momentum comments				400,012	
Project Management			5%	\$1,991	EPA Guidance
				4	
Monitoring Report Total				\$41,803	

Description:

Assumes a Mid Level Engineers/Scientists would be at the site for the entire duration of injections.

The project manager would be onsite one day per week

No overlap of injections would occur. Total treatment duration =

22 weeks for the first injection event and

6 weeks for the second injection event

	Description	Qty	UOM	Unit Cost		Total	Notes
	Droinet Manager	220	hour	\$175		\$38,500	Professional Judgment
	Project Manager		hour				S .
	Mid Level Engineer	1210	hour	\$146		\$176,660	Professional Judgment
Oversight Personnel (1st event)	Mid Level Scientist	1210	hour	\$130		\$157,300	Professional Judgment
	Rental Truck	44	weeks	\$350		\$15,400	Online pricing, includes fuel
	Per diem	308	days	\$384		\$118,272	GSA 2018 rates
					Subtotal	\$506,132	
	Project Manager	60	hour	\$175		\$10,500	Professional Judgment
	Mid Level Engineer	330	hour	\$146		\$48,180	Professional Judgment
Oversight Personnel (2nd event)	Mid Level Scientist	330	hour	\$130		\$42,900	Professional Judgment
	Rental Truck	12	weeks	\$350		\$4,200	Online pricing, includes fuel
	Per diem	84	days	\$384		\$32,256	GSA 2018 rates
					Subtotal	\$138,036	

